FINAL

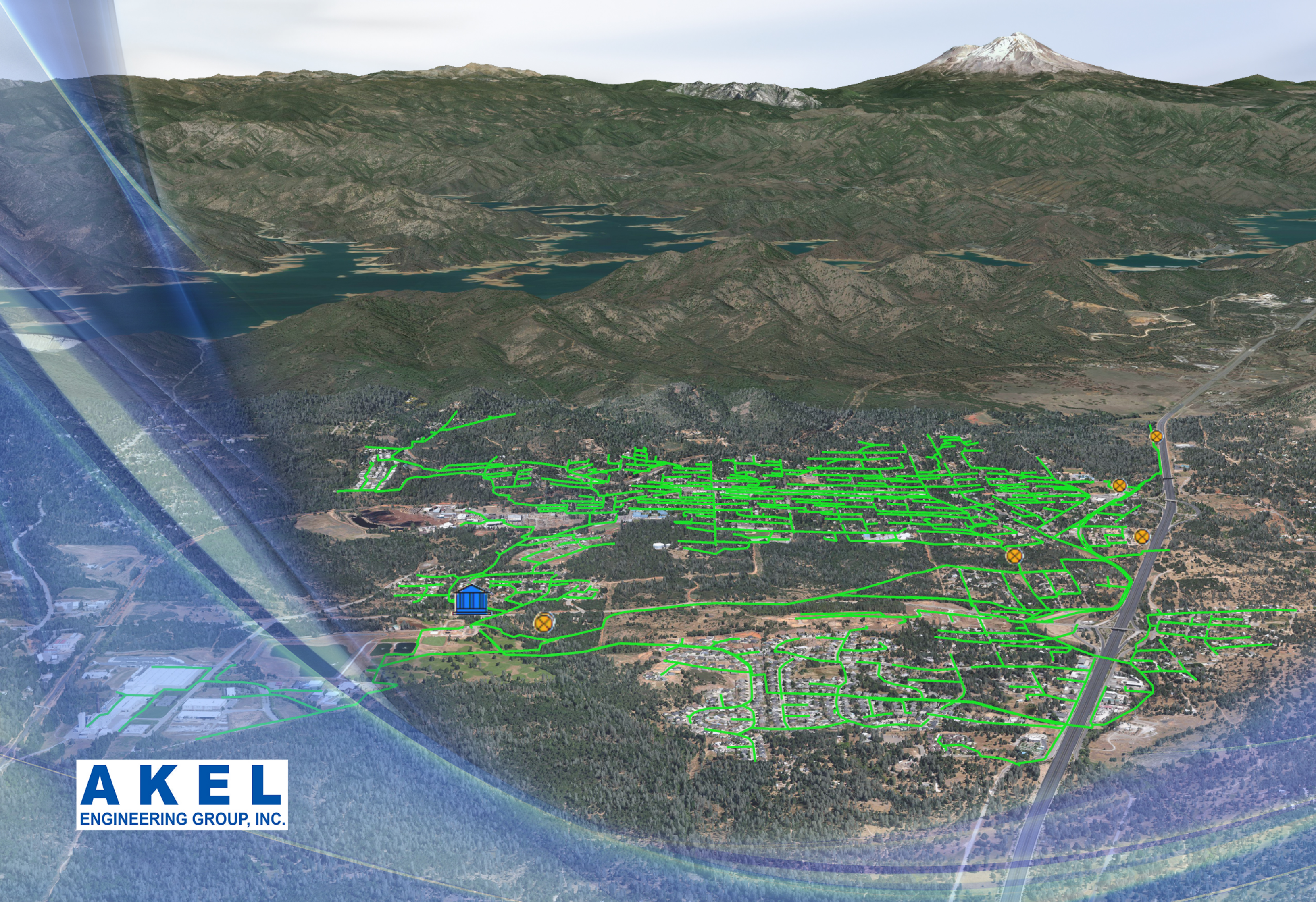
CITY OF SHASTA LAKE

Founded July 2, 1993

City of Shasta Lake

2016-2026 Wastewater Master Plan

December 2016



AKEL ENGINEERING GROUP, INC.

CITY OF SHASTA LAKE

2016

WASTEWATER MASTER PLAN

Final

December 2016

REGISTERED PROFESSIONAL ENGINEER
ANTOINE A AKEL
C 041682
CIVIL
STATE OF CALIFORNIA
12/23/16

AKEL
ENGINEERING GROUP, INC.

City of Shasta Lake
Wastewater Master Plan

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EXECUTIVE SUMMARY

This executive summary presents a brief background of the City of Shasta Lake's wastewater collection system, the planning area characteristics, the planning and design criteria, the hydraulic model development, and the pipeline condition assessment.

The hydraulic model was used to evaluate the capacity adequacy of the existing wastewater collection system and for recommending improvements to mitigate existing deficiencies and for servicing future growth.

ES.1 STUDY OBJECTIVES

The City of Shasta Lake (City) recognizes the importance of planning, developing, and financing the City's wastewater collection system facilities. In order to continue providing reliable and enhanced service to existing customers and to serve anticipated future developments, the City selected Akel Engineering Group, Inc to complete this 2016 Wastewater Master Plan (WWMP). This 2016 WWMP is intended to serve as a tool for planning and phasing the construction of future wastewater collection system facilities for the City's projected planning horizon. The 2016 WWMP evaluates the City's wastewater system and recommends capacity improvements necessary to service the needs of existing users and for servicing the future growth of the City.

The General Plan planning horizon is greater than the projected planning horizon of this master plan. Should planning conditions change, and depending on their magnitude, adjustments to the master plan recommendations might be necessary.

The project included the following major tasks:

- Summarize the City's existing wastewater collection system facilities.
- Document growth planning assumptions and known future developments.
- Summarize the wastewater collection system performance criteria and design storm event.
- Project future wastewater flows.
- Develop and calibrate a new hydraulic model based on the City's Geographic Information Systems (GIS).
- Evaluate the adequacy of capacity for the wastewater collection system facilities to meet existing and projected peak dry weather flows and peak wet weather flows.
- Recommend a capital improvement program (CIP) with an opinion of probable construction costs.
- Perform a capacity allocation analysis for cost sharing purposes between existing users and future growth.

- Develop a Wastewater Master Plan Report.

ES.2 STUDY AREA DESCRIPTION

The City is located in Shasta County in the northern part of California known as Sacramento Valley, approximately 6 miles north of the city of Redding and 150 miles north of the city of Sacramento. Interstate 5 runs in a northeast-southwest direction along the east side of the City. The city limits currently encompass 10.9 square miles, with an estimated population of 10,541 residents according to California Department of Finance (DOF) population estimates.

A developed area to the west of the City, known as Summit City, is part of the City's water service area but not part of the City's sewer service area. For the purpose of this master plan, the sewer service area population is calculated as the City population less the estimated Summit City population.

The City is generally bound to the north by United States Forest Service Land, to the east by Lake Boulevard, to the west by Interstate 5, and to the south by the city of Redding. There are several small creeks that traverse central and western portions of City. The topography consists of southern Cascade foothills, with elevations ranging from 670 feet in the south to approximately 1,000 feet in the northwest. **Figure ES.1** displays the city limits, which represent the planning area of the City's General Plan.

ES.3 SYSTEM PERFORMANCE AND DESIGN CRITERIA

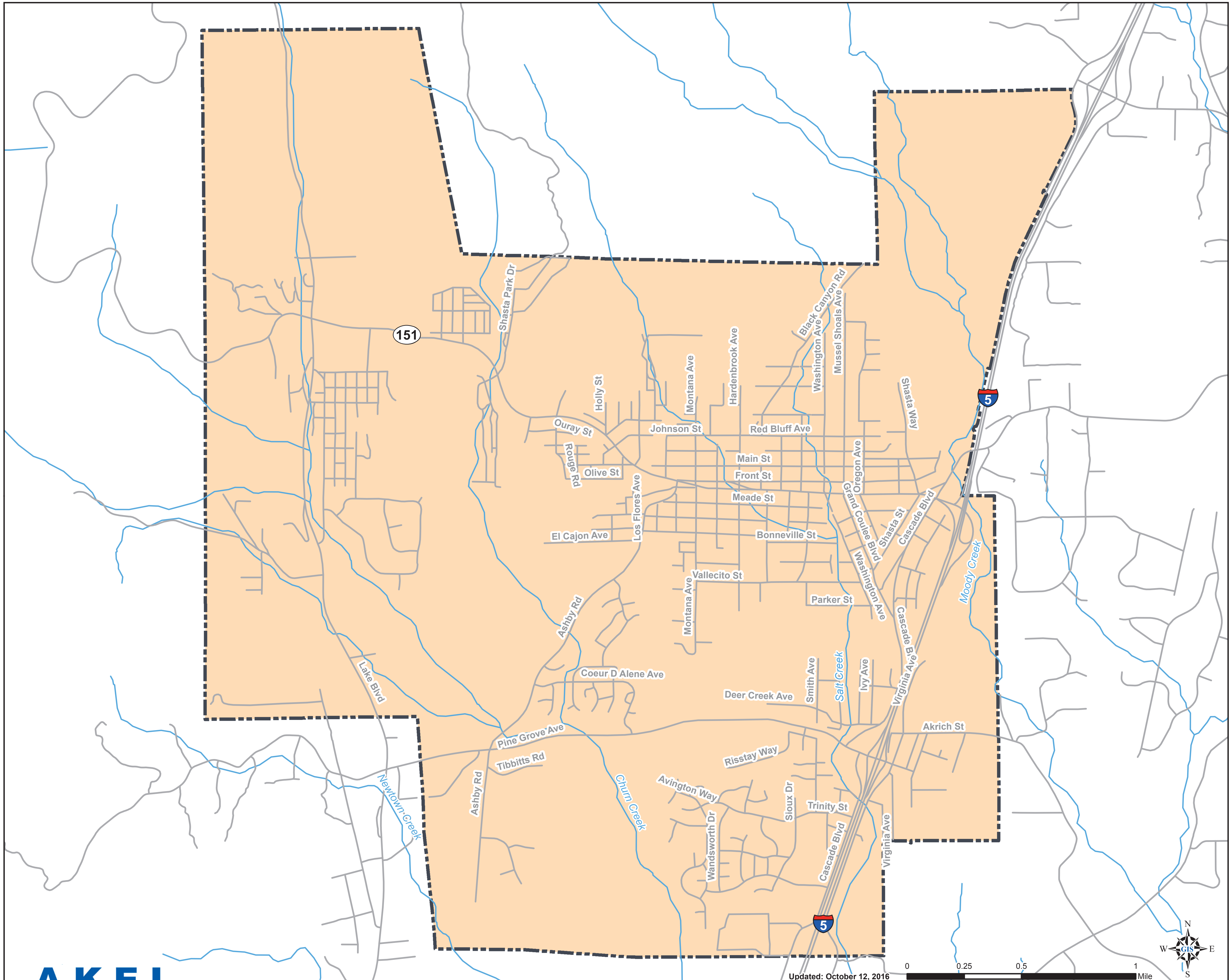
Gravity sewer capacities depend on several factors including: material and roughness of the pipe, the limiting velocity and slope, and the maximum allowable depth of flow. Design criteria include capacity requirements for the wastewater collection system facilities, flow calculation methodologies for future users, and accounting for infiltration and inflows.

Partial Flow Criteria (d/D)

Partial flow in gravity sewers is expressed as a depth of flow to pipe diameter ratio (d/D). For circular gravity conduits, the highest capacity is generally reached at 92 percent of the full height of the pipe (d/D ratio of 0.92). This is due to the additional wetted perimeter and increased friction of a gravity pipe.

During peak dry weather flows (PDWF), the maximum allowable d/D ratio for proposed pipes of all sizes is 0.75. The maximum allowable d/D ratio for all existing pipes (all diameters) is 0.92. The criterion for existing pipes is relaxed in order to maximize the use of the existing pipes before costly pipes improvements are required.

During peak wet weather flows (PWWF), to avoid premature or unnecessary trunk line replacements, the capacity analysis allowed the d/D ratio to exceed the dry weather flow criteria and surcharge. This condition is evaluated using the dynamic hydraulic model and the criteria that



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Legend

- City Limits
- Street Centerlines
- Rivers/Streams

ES.1
Planning Area

Wastewater Master Plan
City of Shasta Lake

stipulates that the hydraulic grade line (HGL), even during a surcharged condition, should be at least three foot below the manhole rim elevation.

The City's design standards pertaining to the d/D criteria are summarized in **Table ES.1**.

ES.4 EXISTING WASTEWATER COLLECTION SYSTEM OVERVIEW

The City provides wastewater collection services to approximately 3,800 residential, commercial, industrial, and institutional accounts. The City's collection system consists of approximately 54 miles of up to 21-inch gravity sewer pipes that convey flows towards the Shasta Lake WWTP, on Pine Grove Avenue as shown on **Figure ES.2**.

A system-wide pipe inventory, listing the total length by pipe diameter, is shown on **Table ES.2**. This table is based on information extracted from the City's GIS. The 6-inch and 8-inch diameter pipes account for 93 percent of the total gravity main pipe lengths.

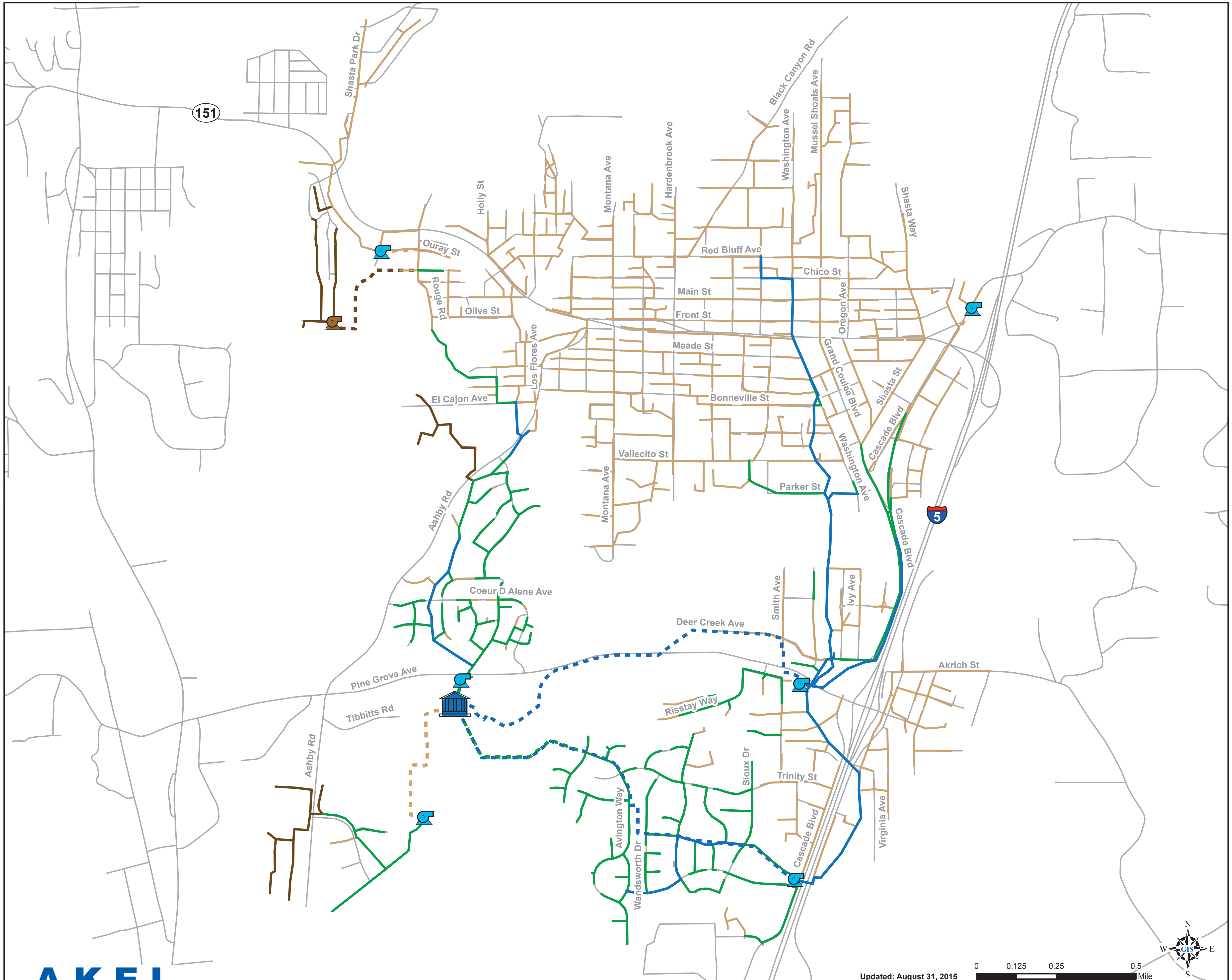
ES.5 WASTEWATER FLOWS

The wastewater flows collected and treated at the Shasta Lake WWTP vary monthly, daily, and hourly. While the dry weather flows are influenced by customer uses, the wet weather flows are influenced by the severity and length of storm events. Flow data influent to the Shasta Lake WWTP was obtained from City operation staff. The flow data covered a period from 2004 to 2014. From this data monthly, daily, peak daily flows, and peak hourly flows (if available), were determined as summarized on **Table ES.3**. Flows for future development were based on their respective land use and corresponding flow factors and are documented on **Table ES.4**.

ES.6 HYDRAULIC MODEL DEVELOPMENT AND CALIBRATION

The City's hydraulic model combines information on the physical characteristics of the wastewater collection system (pipelines, lift stations) and operational characteristics (how they operate). The hydraulic model then performs calculations and solves series of equations to simulate flows in pipes, including backwater calculations for surcharged conditions. Computer modeling requires the compilation of large numerical databases that enable data input into the model. Detailed physical aspects, such as pipe size, ground elevation, invert elevations, and pipe lengths contribute to the accuracy of the model.

The hydraulic modeling software used for evaluating the capacity adequacy of the City wastewater collection system, InfoSewer by Innovyze Inc., uses the simplified St. Venant's equation, which is utilized to simulate backwater and surcharge conditions, in addition to simulating manifolded force mains. The software also incorporates the use of the Manning Equation in other calculations including upstream pipe flow conditions. The St Venant's and Manning's equations are discussed in the System Performance and Design Criteria chapter.



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Legend

Existing System

- WWTP
- Lift Stations
- Private Lift Station

Force Mains

- 6" or Smaller
- 8"
- 10" or Larger
- Private Force Mains

Gravity Mains

- 6" or Smaller
- 8"
- 10" or Larger
- Private Gravity Mains
- Street Centerlines

ES.2
Existing Wastewater Collection System

Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

Table ES.1 Performance and Design Criteria
Wastewater Master Plan
City of Shasta Lake

Pipeline Criteria

Peak Dry Weather Flow Criteria

Diameter (in)	Maximum Allowable d/D	
	Existing Trunks	Proposed Trunks
Any Pipe Size	**0.92**	**0.75**

Peak Wet Weather Flow Criteria

Hydraulic Grade Line (HGL) should be **3 feet** below the manhole rim

Average Dry Weather Flow HE Criteria

1 HE = 170 gpd

Dry Weather Flow Peaking Factor

Peak Dry Weather Flow = **1.7** x Average Dry Weather Flow

Lift Station Capacity

Lift Station capacity shall be sized to meet PWWF with largest unit out of service

Pipe Size	Minimum Grade	Capacity (n = 0.013)	
(in)	(ft/ft)	(mgd)	(cfs)
8	0.0040	0.50	0.77
10	0.0030	0.78	1.20
12	0.0025	1.15	1.79
15	0.0014	1.59	2.45
18	0.0011	2.28	3.53
21	0.0009	3.11	4.81
24	0.0008	4.06	6.28
27	0.0007	5.14	7.95
30	0.0006	6.34	9.81
33	0.0005	7.67	11.88

Table ES.2 Existing GIS Pipe Inventory
Wastewater Master Plan
City of Shasta Lake

Pipe Size (in)	Pipe Length (ft)	(miles)
Gravity Mains		
6	195,498	37.0
8	70,775	13.4
10	7,902	1.5
12	5,973	1.1
14	147	0.0
15	2,876	0.5
18	2,830	0.5
21	673	0.1
Subtotal	286,672	54.3
Force Mains		
4	421	0.1
6	3,322	0.6
8	3,082	0.6
10	6,880	1.3
14	8,055	1.5
Subtotal	21,760	4.1
Total		
	308,432	**58.4**

5/6/2016

Table ES.3 Historical Wastewater Treatment Plant Flows

Wastewater Master Plan
City of Shasta Lake

Year	Average Annual Flow	Seasonal Average		Maximum Month				Maximum Day					Peak Hour			
				MMDWF		MMWWF		MDDWF		MDWWF			PHDWF		PHWWF	
		ADWF	AWWF	Flow	Month of Occurrence	Flow	Month of Occurrence	Flow	Day of Occurrence	Flow	Day of Occurrence	Previous Week	Flow	Day of Occurrence	Flow	Day of Occurrence
	(MGD)	(MGD)	(MGD)	(MGD)		(MGD)		(MGD)		(MGD)		(in)	(MGD)		(MGD)	
2004	1.01	0.69	1.08	0.69	August	1.74	February	0.84	August 23	3.36	February 17	8.2	---	---	---	---
2005	1.05	0.74	1.11	0.79	July	1.65	December	0.99	July 16	4.19	December 31	11.7	---	---	---	---
2006	1.07	0.69	1.15	0.70	August	1.68	March	0.92	July 8[4]	3.45	January 2	11.6	1.20	July 7	3.65	January 1
2007	0.88	0.68	0.92	0.69	July	1.47	February	0.91	July 19	4.06	February 11	5.9	---	---	---	---
2008	0.92	0.66	0.97	0.68	July	1.52	February	0.87	July 6	3.14	February 3	5.1	---	---	---	---
2009	0.90	0.64	0.96	0.65	July	1.43	February	0.77	August 2	2.67	February 24	6.5	---	---	---	---
2010	1.03	0.65	1.12	0.66	July	1.70	January	0.75	July 12	2.99	January 22	10.7	---	---	---	---
2011	0.91	0.66	0.96	0.70	July	1.71	March	0.88	July 1	2.95	March 27	7.0	---	---	---	---
2012	0.88	0.56	0.94	0.57	July	1.71	December	0.65	August 20	2.88	December 24	6.7	---	---	---	---
2013	0.71	0.57	0.74	0.59	July	1.00	April	0.74	July 1	1.73	April 5	3.3	---	---	---	---
2014	0.78	0.47	0.84	0.47	July	1.65	December	0.54	August 18	3.13	December 12	9.6	0.80	August 17	5.00[5]	December 12
Historical Peaking Factors (applied to ADWF)																
2004	1.47	1.00	1.56	1.00		2.53		1.22		4.88			---		---	
2005	1.41	1.00	1.50	1.06		2.23		1.33		5.64			---		---	
2006	1.55	1.00	1.66	1.01		2.44		1.33		5.00			1.74		5.29	8.40
2007	1.30	1.00	1.36	1.02		2.18		1.35		6.01			---		---	
2008	1.38	1.00	1.46	1.02		2.29		1.31		4.73			---		---	
2009	1.42	1.00	1.50	1.02		2.24		1.21		4.18			---		---	
2010	1.58	1.00	1.72	1.02		2.61		1.15		4.60			---		---	
2011	1.37	1.00	1.45	1.06		2.58		1.33		4.46			---		---	
2012	1.56	1.00	1.67	1.01		3.04		1.15		5.10			---		---	
2013	1.25	1.00	1.30	1.03		1.77		1.30		3.05			---		---	
2014	1.66	1.00	1.80	1.00		3.52		1.15		6.68			1.71		10.66	
Peaking Factor Analysis																
10-Year Average		1.00	1.54	1.03		2.49		1.26		4.95			---		---	
10-Year Maximum		1.00	1.80	1.06		3.52		1.35		6.68			---		---	
5-Year Average		1.00	1.59	1.02		2.70		1.22		4.78						
5-Year Maximum		1.00	1.80	1.06		3.52		1.33		6.68			1.12		3.41	
Last Year		1.00	1.80	1.00		3.52		1.15		6.68			1.71		10.66	
Recommended Factor		**1.00**	**1.75**	**1.00**		**3.00**		**1.35**		**6.00**						

Notes:

5/6/2016

1. Definitions are as follows:
   - AAF - Average Annual Flow (annual flow, expressed in daily or other time units)
   - ADWF - Average Dry Weather Flow (average flow that occurs on a daily basis during the dry weather season)
   - AWWF - Average Wet Weather Flow (average flow that occurs on a daily basis during the wet weather season)
   - MMDWF - Maximum Month Dry Weather Flow (maximum month flow during the dry weather season)
   - MMWWF - Maximum Month Wet Weather Flow (maximum month flow during the wet weather season)
   - MDDWF - Maximum Day Dry Weather Flow (highest measured daily flow that occurs during a dry weather season)
   - MDWWF - Maximum Day Wet Weather Flow (highest measured daily flow that occurs during a wet weather season)

2. Based on historical rainfall data, the dry weather season is taken to be the months of July and August. All other months considered part of the wet weather season.

3. March 2010 flow data was unusable and not included in the historical flow tabulation.

4. The MDDWF for 2006 occurred on August 29. However, according to City staff per conversation October 26, 2015, the recorded value of 1.26 MGD was an anomaly due to mechanical failure; the next highest MDDWF is shown above.

5. The peak hour flow during the 2014 wet weather event exceeded the operating range of the data recorder for approximately 3 hours; therefore the value shown is the maximum recordable value, not necessarily the actual peak hour wet weather flow.

Table ES.4 Future Development ADWF

Wastewater Master Plan

City of Shasta Lake

Growth Focus Area	Average Dry Weather Flows		
	Residential (mgd)	Non-Residential (mgd)	Subtotal (mgd)
10-Year Planning Horizon			
4A	-	0.024	0.024
4B	0.001	0.018	0.019
4L	0.031	-	0.031
1D	-	0.023	0.023
Total	**0.032**	**0.065**	**0.097**
20-Year Planning Horizon			
1A	0.000	0.010	0.011
1B	0.001	0.008	0.008
1C	0.001	0.003	0.005
1E	0.003	0.003	0.006
1F	-	0.006	0.006
Mountain Gate	-	0.335	0.335
Total	**0.006**	**0.365**	**0.371**

Note: 10/20/2016

1. Dashed value indicates a value of zero for future residential and non-residential average dry weather flow.

Model Development

City staff maintains a GIS record of the wastewater collection system. The City has recently completed a system-wide closed-circuit television (CCTV) program for sewer mains, and some manhole field survey information such as rim elevations, pipe invert elevations, as well as the physical manhole location. This GIS data was the basis for developing the hydraulic model used in the capacity evaluation of the wastewater collection system.

The City's wastewater collection system was skeletonized to reduce the model from approximately 1,200 pipes extracted from the GIS to 300 pipes. The modeled pipes included pipes 6-inches in diameter and larger. The modeled wastewater collection system is shown on **Figure ES.3**.

Model Calibration

Calibration can be performed for steady state conditions, which model the peak hour flows, or for dynamic conditions (24 hours or more). The calibration process was iterative as it involved calibrating the model for the three calibration conditions: 1) peak dry weather flow, 2) peak wet weather flows from storm rainfall Event No. 1, and 3) peak wet weather flows from storm rainfall Event No. 2.

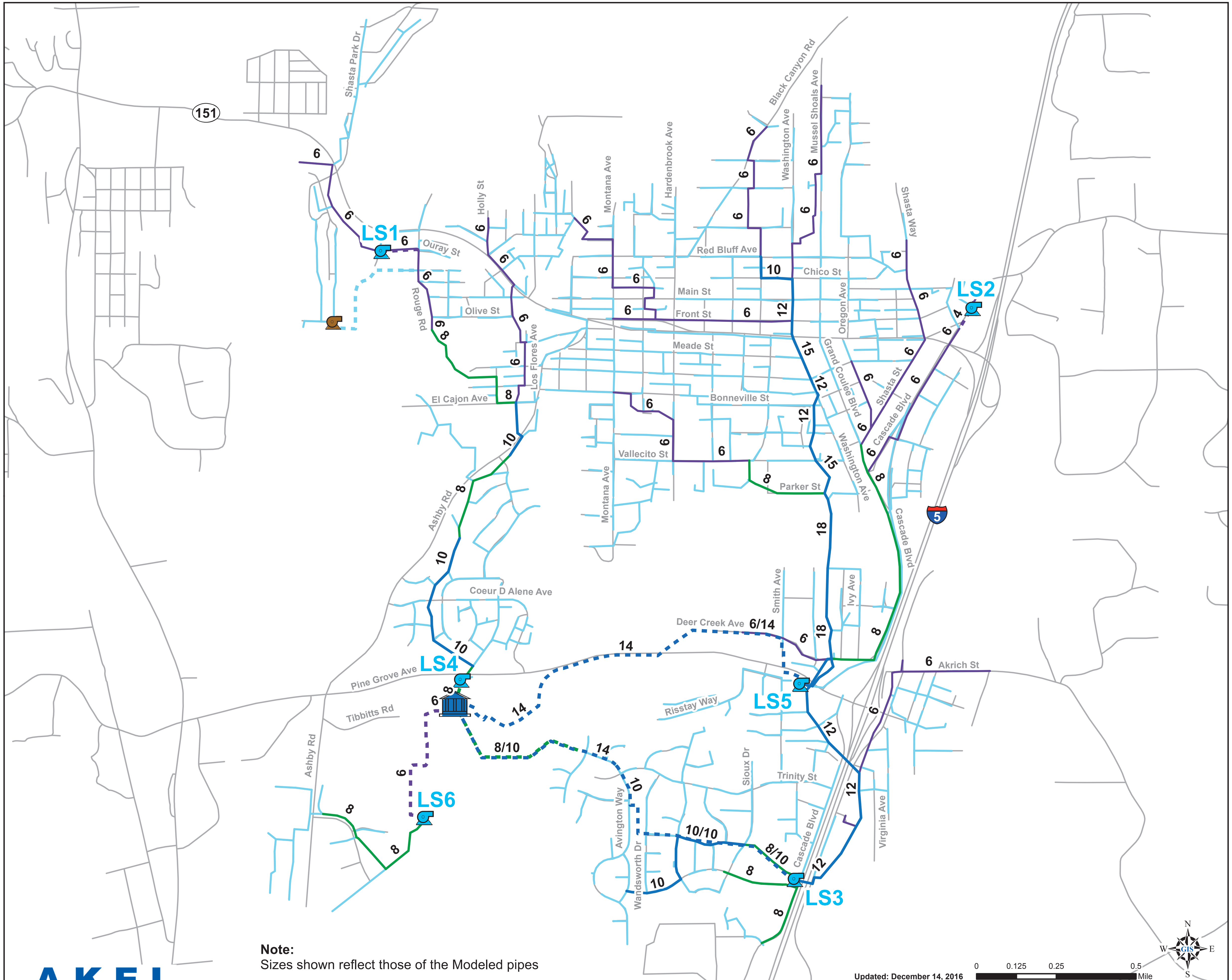
The calibrated hydraulic model was used as an established benchmark in the capacity evaluation of the existing wastewater collection system. The model was also used to identify improvements necessary for mitigating existing system deficiencies and for accommodating future growth.

The hydraulic model is a valuable investment that will continue to prove its worth to the City as future planning issues or other operational conditions surface. It is recommended that the model be maintained and updated with new construction projects to preserve its integrity.

ES.7 CAPACITY EVALUATION

The calibrated hydraulic model was used for evaluating the wastewater collection system for capacity deficiencies during peak dry weather flows (PDWF) and peak wet weather flows (PWWF). The system performance and design criteria were used as a basis to judge the adequacy of capacity for the existing wastewater collection system. The design flows simulated in the hydraulic model for existing conditions, 10-year planning horizon, and 20-year planning horizon include:

- Existing PDWF = 2.1 MGD
- Existing PWWF = 4.8 MGD
- 10-Year PDWF = 2.3 MGD
- 10-Year PWWF = 5.1 MGD
- 20-Year PDWF = 3.0 MGD
- 20-Year PWWF = 6.8 MGD



ES.3
Existing Modeled Wastewater Collection System
Wastewater Master Plan
City of Shasta Lake

In general, the hydraulic model indicated that the wastewater collection system exhibited acceptable performance to service the existing customers during both peak dry weather flows and peak wet weather flows. Future flows were then added to the hydraulic model and the existing system was expanded in order to serve these future customers. The proposed improvements for the future system are shown with pipe sizes on an overall exhibit on **Figure ES.4**.

ES.8 CONDITION ASSESSMENT

The City has recently completed a system-wide CCTV assessment of the wastewater collection system, and provided the information as part of this master plan. The CCTV was reviewed to identify additional critical capital improvement projects based on the condition of the pipelines.

The condition of the wastewater pipes was evaluated to identify pipes in poor condition and prioritize improvements. The condition assessment involved CCVTV of wastewater pipes, and which was completed in accordance with the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) standards. This included determining structural, operational and maintenance, construction, and miscellaneous defects.

Improvements types associated with the pipeline rehabilitation are documented on **Figure ES.4** and described as follows:

- **Defect Repair:** Pipes identified as having point defects are recommended for repair. Due to the uncertain nature of the point repair, and for estimating purposes, ten feet upstream and ten feet downstream of each defect are assumed in the length of repair.

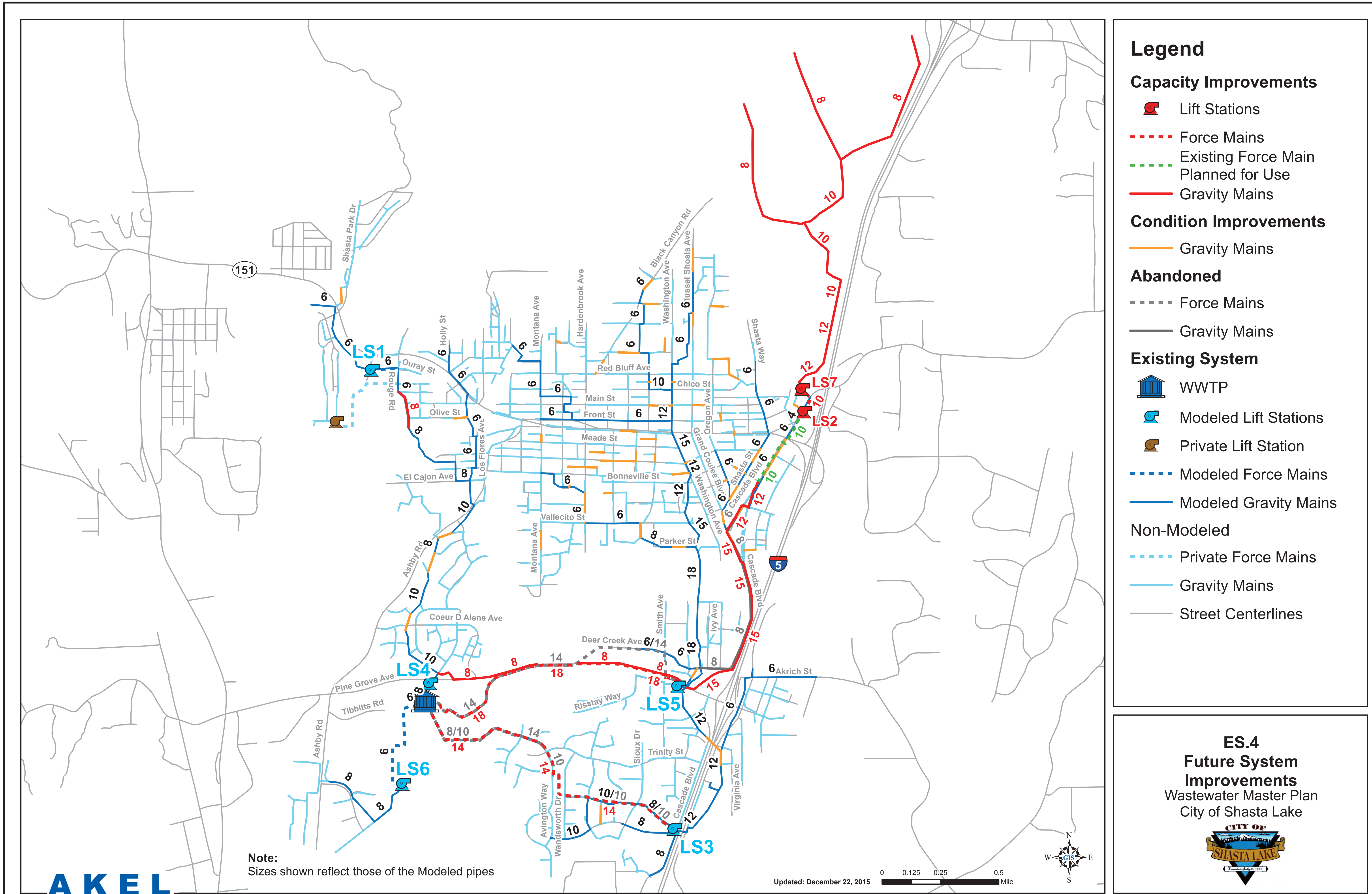
- **Pipeline Replacement:** Based on the results of the condition assessment it was determined that the replacement of the existing pipe was required to mitigate existing system defects.

- **Infiltration Repair:** Pipelines with significant infiltration and inflow defects are recommended for repair known as cured in place pipe (CIPP).

ES.9 CAPITAL IMPROVEMENT PROGRAM

The Capital Improvement Program includes pipeline, lift station, and pipeline rehabilitation projects recommended in this master plan (**Table ES.5**). Each improvement was assigned a uniquely coded identifier that is used for locating it on the corresponding figures.

The estimated construction costs include the baseline costs plus **25 percent** contingency allowance to account for unforeseen events and unknown field conditions. Capital improvement costs include the estimated construction costs plus **25 percent** project-related costs (engineering design, project administration, construction management and inspection, and legal costs). The costs in this WWMP were benchmarked using a 20-City national average ENR CCI of 10,386, reflecting a date of August 2016.


Legend
Capacity Improvements
Lift Stations
Force Mains
Existing Force Main Planned for Use
Gravity Mains
Condition Improvements
Gravity Mains
Abandoned
Force Mains
Gravity Mains
Existing System
WWTP
Modeled Lift Stations
Private Lift Station
Modeled Force Mains
Modeled Gravity Mains
Non-Modeled
Private Force Mains
Gravity Mains
Street Centerlines
ES.4
Future System Improvements
Wastewater Master Plan
City of Shasta Lake
CITY OF SHASTA LAKE
Note:
Sizes shown reflect those of the Modeled pipes
AKEL ENGINEERING GROUP, INC.
Updated: December 22, 2015
0 0.125 0.25 0.5 Mile
N S E W
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LS1
LS2
LS3
LS4
LS5
LS6
LS7
151
5
Shasta Park Dr
Ouray St
Rouge Rd
Olive St
Holly St
Los Flores Ave
El Cajon Ave
Ashby Rd
Coeur D Alene Ave
Pine Grove Ave
Tibbitts Rd
Montana Ave
Hardenbrook Ave
Black Canyon Rd
Washington Ave
Mussel Shoals Ave
Red Bluff Ave
Chico St
Main St
Front St
Meade St
Bonneville St
Vallecito St
Parker St
Oregon Ave
Grand Coulee Blvd
Shasta Way
Shasta St
Cascade Blvd
Deer Creek Ave
Smith Ave
Ivy Ave
Akrich St
Rissay Way
Sioux Dr
Trinity St
Virginia Ave
Avington Way
Wandsworth Dr

Table ES.5 Capital Improvement Program

Wastewater Master Plan
City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements: Existing Diameter	Pipeline Improvements: New/ Suggested Rehabilitation	Infrastructure Costs: Diameter	Infrastructure Costs: Length	Infrastructure Costs: Unit Cost	Infrastructure Costs: Infr. Cost	Baseline Constr. Costs[1]	Estimated Constr. Costs[1,2]	Capital Improv. Costs[1,3]	Construction Trigger	Suggested Phasing	Suggested Cost Allocation: Existing Users	Suggested Cost Allocation: Future Users	Cost Allocation: Existing Users	Cost Allocation: Future Users
				(in)		(in)	(ft)	($/unit)	($)	($)	($)	($)			(%)	(%)	($)	($)
Capacity Improvements																		
Pipeline Capacity Improvements																		
PC-1	Gravity Main	Rogue Rd	From Conchas St to 240' s/o Olive St	6	Replace	8	950	174	165,727	165,727	207,158	258,948	Immediate	10 Year	100%	0%	258,948	0
PC-2	Gravity Main	Future ROW	From 1,000' n/o Cascade Blvd to Future LS7	-	New	12	1,300	222	289,184	289,184	361,480	451,850	Construct with development	10 Year	0%	100%	0	451,850
PC-3	Force Main	Future ROW	From LS7 to 270' ne/o intersection of Cascade Blvd and Kennett St	-	New	10	625	198	124,031	124,031	155,038	193,798	Immediate	10 Year	0%	100%	0	193,798
PC-4	Force Main	Existing ROW	From LS3 to WWTP	8/10/14	Replace	14	7,525	246	1,851,150	1,851,150	2,313,938	2,892,422	Immediate	10 Year	95%	5%	2,747,801	144,621
PC-5	Gravity Main	Pine Grove Ave	From 1,700' w/o Jorzack Way to 350' w/o Cascade Blvd	-	New	8	2,525	174	440,484	440,484	550,605	688,256	Construct with development	10 Year	0%	100%	0	688,256
PC-6	Gravity Main	Pine Grove Ave	From 1,600' e/o Coeur D'Alene Ave to 800' w/o Coeur D'Alene Ave	-	New	8	2,375	174	414,316	414,316	517,895	647,369	Construct with development	10 Year	0%	100%	0	647,369
PC-7	Force Main	ROW 60' s/o Pine Grove Ave	From LS5 to WWTP	14	Replace	18	6,775	294	1,994,892	1,994,892	2,493,615	3,117,019	Construct with development	10 Year	53%	47%	1,638,492	1,478,527
PC-8	Gravity Main	ROW	From 4,400' nw/o intersection of Walker Ln and Black Canyon Rd to 4,000' n/o Cascade Blvd	-	New	8	3,550	174	619,294	619,294	774,117	967,647	Construct with development	20 Year	0%	100%	0	967,647
PC-9	Gravity Main	ROW	From 3,700' w/o intersection of HWY-5 and Old Oregon Trl to 4,100' sw/o intersection of HWY-5 and Old Oregon Trl	-	New	8	2,625	174	457,929	457,929	572,411	715,513	Construct with development	20 Year	0%	100%	0	715,513
PC-10	Gravity Main	ROW	From 1,100' w/o intersection of HWY-5 and Old Oregon Trl to 4,100' sw/o intersection of HWY-5 and Old Oregon Trl	-	New	8	3,675	174	641,100	641,100	801,375	1,001,719	Construct with development	20 Year	0%	100%	0	1,001,719
PC-11	Gravity Main	ROW	From 4,100' sw/o intersection of HWY-5 and Old Oregon Trl to 4,000' n/o Cascade Blvd	-	New	10	1,900	198	377,053	377,053	471,316	589,145	Construct with development	20 Year	0%	100%	0	589,145
PC-12	Gravity Main	ROW	From 4,000' n/o Cascade Blvd to 1,900' ne/o Cascade Blvd	-	New	10	2,500	198	496,123	496,123	620,153	775,191	Construct with development	20 Year	0%	100%	0	775,191
PC-13	Gravity Main	ROW	From 1,900' ne/o Cascade Blvd to 1,000' n/o Cascade Blvd		New	12	725	222	161,276	161,276	201,594	251,993	Construct with development	20 Year	0%	100%	0	251,993
PC-14	Gravity Main	Cascade Blvd	From Bonneville St to Joseph St	-	New	12	650	222	144,592	144,592	180,740	225,925	Construct with development	20 Year	100%	0%	225,925	0
PC-15	Gravity Main	Joseph St	From Cascade Blvd to Morning Star Way	6	Replace	12	150	222	33,367	33,367	41,709	52,136	332 HEs	20 Year	6%	94%	3,342	48,795
PC-16	Gravity Main	Morning Star Way	From Joseph St to Grand Coulee Blvd	6	Replace	12	725	222	161,276	161,276	201,594	251,993	397 HEs	20 Year	7%	93%	17,192	234,801
PC-17	Gravity Main	Grand Coulee Blvd	From Morning Star Way to Cascade Blvd	8	Replace	15	825	258	213,220	213,220	266,526	333,157	281 HEs	20 Year	15%	85%	49,512	283,645
PC-18	Gravity Main	Cascade Blvd	From Grand Coulee Blvd to Pine Grove Ave	8	Replace	15	3,725	258	962,723	962,723	1,203,403	1,504,254	880 HEs	20 Year	10%	90%	152,644	1,351,610
						Subtotal - Pipeline Capacity Improvements				9,547,734	11,934,668	14,918,335					**5,093,855**	**9,824,480**
Lift Station Capacity Improvements						Lift Station Capacity (mgd)												
LS-2[4]	Lift Station	Cascade Blvd 700' n/o Shasta Dam Blvd			Replace			-	320,000	320,000	-	-	Construct with development		60%	40%	192,000	128,000
LS-7	Lift Station	Cascade Blvd 700' n/o Shasta Dam Blvd			New	1.6		-	1,014,163	1,014,163	1,267,704	1,584,630	Construct with development		0%	100%	0	1,584,630
						Subtotal - Lift Station Capacity Improvements				1,334,163	1,267,704	1,584,630					**192,000**	**1,712,630**
Pipeline Rehabilitation Improvements																		
Pipeline Replacement Improvements																		
PR-1	Gravity Main	ROW 50' n/o Gray Pine Way	From Locust St to 100' e/o Locust St	6	Replace	8	100	174	17,445	17,445	21,806	27,258	Immediate	10 Year	100%	0%	27,258	0
PR-2	Gravity Main	Black Canyon Rd	From Walker St to 315' n/o Boca St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-4	Gravity Main	Pensacola St	From 230' e/o Black Canyon Rd to 220' w/o Grand River Ave	6	Replace	8	475	174	82,863	82,863	103,579	129,474	Immediate	10 Year	100%	0%	129,474	0
PR-5	Gravity Main	ROW 180' w/o Washington Ave	From 300' n/o Pensacola St to Pensacola St	6	Replace	8	300	174	52,335	52,335	65,418	81,773	Immediate	10 Year	100%	0%	81,773	0
PR-6	Gravity Main	Mussel Shoals Ave	From 230' n/o Koch Rd to 300' s/o Koch Rd	6	Replace	8	500	174	87,225	87,225	109,031	136,288	Immediate	10 Year	100%	0%	136,288	0
PR-7	Gravity Main	Kevin Ln	From Eugene Ave to 300' e/o Eugene Ave	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-8	Gravity Main	Mussel Shoals Ave	From 1,100' n/o Red Bluff St to 1,400' n/o Red Bluff St	6	Replace	8	275	174	47,973	47,973	59,967	74,959	Immediate	10 Year	100%	0%	74,959	0
PR-13	Gravity Main	Main St	From 315' e/o Mussels Shoals Ave to Mussel Shoals Ave	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-14	Gravity Main	ROW 180' e/o Oregon St	From 175' n/o Front St to Front St	6	Replace	8	175	174	30,529	30,529	38,161	47,701	Immediate	10 Year	100%	0%	47,701	0
PR-15	Gravity Main	ROW 330' n/o Kennett St	From 200' w/o Cascade Blvd to Cascade Blvd	6	Replace	8	200	174	34,890	34,890	43,612	54,515	Immediate	10 Year	100%	0%	54,515	0
PR-16	Gravity Main	Cascade Blvd	From Shasta Dam Blvd to Second St	6	Replace	8	375	174	65,418	65,418	81,773	102,216	Immediate	10 Year	100%	0%	102,216	0

Table ES.5 Capital Improvement Program

Wastewater Master Plan
City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/ Suggested Rehabilitation	Infrastructure Costs: Diameter (in)	Infrastructure Costs: Length (ft)	Infrastructure Costs: Unit Cost ($/unit)	Infrastructure Costs: Infr. Cost ($)	Baseline Constr. Consts[1] ($)	Estimated Constr. Costs[1,2] ($)	Capital Improv. Costs[1,3] ($)	Construction Trigger	Suggested Phasing	Suggested Cost Allocation: Existing Users (%)	Suggested Cost Allocation: Future Users (%)	Cost Allocation: Existing Users ($)	Cost Allocation: Future Users ($)
PR-18	Gravity Main	Morning Star Way	From Joseph St to 330' s/o Joseph St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-19	Gravity Main	Bonneville St	From 320' w/o Shasta St to Shasta St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-20	Gravity Main	Boulder St	From 180' w/o Oregon St to Oregon St	6	Replace	8	175	174	30,529	30,529	38,161	47,701	Immediate	10 Year	100%	0%	47,701	0
PR-21	Gravity Main	Shasta St	From 675' n/o Grand Coulee Blvd to 330' n/o Grand Coulee Blvd	6	Replace	8	350	174	61,057	61,057	76,321	95,402	Immediate	10 Year	100%	0%	95,402	0
PR-22	Gravity Main	Fort Peck St	From 170' e/o Washington Ave to Washington Ave	6	Replace	8	175	174	30,529	30,529	38,161	47,701	Immediate	10 Year	100%	0%	47,701	0
PR-23	Gravity Main	ROW 210' n/o Bonneville St	From 380' w/o Washington Ave to Washington Ave	6	Replace	8	375	174	65,418	65,418	81,773	102,216	Immediate	10 Year	100%	0%	102,216	0
PR-25	Gravity Main	Deer Creek Rd	From 160' n/o Fort Peck St to Fort Peck St	6	Replace	8	150	174	26,167	26,167	32,709	40,886	Immediate	10 Year	100%	0%	40,886	0
PR-26	Gravity Main	Alley n/o Meade St	From 340' w/o Deer Creek Rd to Deer Creek Rd	6	Replace	8	350	174	61,057	61,057	76,321	95,402	Immediate	10 Year	100%	0%	95,402	0
PR-29	Gravity Main	Alley n/o Fort Peck St	From 550' w/o Cabello St to 200' w/o Cabello St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-31	Gravity Main	Alley n/o La Mesa Ave	From 275' e/o Hardenbrook Ave to Hardenbrook Ave	6	Replace	8	275	174	47,973	47,973	59,967	74,959	Immediate	10 Year	100%	0%	74,959	0
PR-33	Gravity Main	ROW 175' e/o Locust Ave	From 120' n/o Winteramber Ct to Winter Amber Ct	6	Replace	8	125	174	21,806	21,806	27,258	34,072	Immediate	10 Year	100%	0%	34,072	0
PR-35	Gravity Main	Montana Ave	From 410' s/o Vallecito St to Vallecito St	6	Replace	8	400	174	69,780	69,780	87,225	109,031	Immediate	10 Year	100%	0%	109,031	0
									Subtotal - Pipeline Condition Replacement Improvements	1,173,170	1,466,462	1,833,077					**1,833,077**	**0**
Defect Repair Improvements																		
PR-3	Gravity Main	Boca St	From 300' w/o Washington Ave to 150' e/o Black Canyon Rd	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-9	Gravity Main	Dyke St	From Oregon St to 350' e/o Oregon St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-10	Gravity Main	ROW 350' e/o Oregon St	From Red Bluff St to Dyke St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-11	Gravity Main	ROW 340' w/o Oregon St	From Red Bluff St cul-de-sac to 90' n/o Chico St cul-de-sac	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-12	Gravity Main	ROW 175' s/o Red Bluff St	From 300' e/o Washington St to Washington St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-17	Gravity Main	Joseph St	From Cascade St to Morning Star Way	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-24	Gravity Main	ROW 300' w/o Ellen Dr	From Vallecito St to 330' s/o Vallecito St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-27	Gravity Main	Shasta Dam Blvd	From 370' w/o Stanton Ave to Stanton Ave	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-28	Gravity Main	Stanton Ave	From 220' n/o Fort Peck St to Fort Peck St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-30	Gravity Main	Fort Peck St	From 300' w/o Cabello St to Cabello St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-32	Gravity Main	Alley n/o La Mesa Ave	From 640' w/o Hardenbrook Ave to Hardenbrook Ave	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-34	Gravity Main	ROW 200' s/o Bonneville St	From 200' w/o Cabello St to Cabello St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-36	Gravity Main	Montana Ave	From 175' n/o Meade St to Meade St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-37	Gravity Main	ROW 100' w/o Shasta Park Dr	From 550' n/o Twin Lake Dr to 210' n/o Twin Lake Dr	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
									Subtotal - Pipeline Defect Repair Improvements	42,126	52,657	65,821					**65,821**	**0**
Infiltration Improvements																		
PI-1	Gravity Main	Boudreaux Pl	From 360' n/o Red Bluff St to Red Bluff St	6	Lining		350	24	8,330	8,330	10,412	13,015	Immediate	10 Year	100%	0%	13,015	0
PI-2	Gravity Main	ROW 150' n/o Chico St	From Grand River Ave to 280' e/o Grand River Ave	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-3	Gravity Main	Main St	From Grand River Ave to Washington Ave	6	Lining		525	24	12,494	12,494	15,618	19,523	Immediate	10 Year	100%	0%	19,523	0
PI-4	Gravity Main	ROW 500' e/o Oregon St	From 50' n/o Shasta Dam Blvd to 30' s/o Shasta Dam Blvd	6	Lining		75	24	1,785	1,785	2,231	2,789	Immediate	10 Year	100%	0%	2,789	0
PI-5	Gravity Main	Shasta St	From Fort Peck St to 320' s/o Fort Peck St	6	Lining		325	24	7,735	7,735	9,668	12,085	Immediate	10 Year	100%	0%	12,085	0
PI-6	Gravity Main	Cascade Blvd	From Shasta Dam Blvd to Second St	6	Lining		375	24	8,925	8,925	11,156	13,945	Immediate	10 Year	100%	0%	13,945	0
PI-7	Gravity Main	Cascade Blvd	From Second St to Third St	6	Lining		500	24	11,899	11,899	14,874	18,593	Immediate	10 Year	100%	0%	18,593	0

Table ES.5 Capital Improvement Program

Wastewater Master Plan
City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements		Infrastructure Costs				Baseline Constr. Consts[1]	Estimated Constr. Costs[1,2]	Capital Improv. Costs[1,3]	Construction Trigger	Suggested Phasing	Suggested Cost Allocation		Cost Allocation	
				Existing Diameter (in)	New/ Suggested Rehabilitation	Diameter (in)	Length (ft)	Unit Cost ($/unit)	Infr. Cost ($)	($)	($)	($)			Existing Users (%)	Future Users (%)	Existing Users ($)	Future Users ($)
PI-8	Gravity Main	Grand Coulee Blvd	From Shasta St to 260' s/o Shasta St	8	Lining		250	37	9,313	9,313	11,641	14,551	Immediate	10 Year	100%	0%	14,551	0
PI-9	Gravity Main	Grand Coulee Blvd	From Morning Star Way to 280' s/o Morning Star Way	8	Lining		275	37	10,244	10,244	12,805	16,006	Immediate	10 Year	100%	0%	16,006	0
PI-10	Gravity Main	ROW 200' s/o Elliott St	From Rosamond St to Cascade Blvd	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-11	Gravity Main	Parker St	From 430' e/o Ellen St to 610' e/o Ellen St	8	Lining		275	37	10,244	10,244	12,805	16,006	Immediate	10 Year	100%	0%	16,006	0
PI-12	Gravity Main	Fort Peck St	From Cabello St to Stanton Ave	6	Lining		500	24	11,899	11,899	14,874	18,593	Immediate	10 Year	100%	0%	18,593	0
PI-13	Gravity Main	Hardenbrook Ave	From 270' n/o Willamette St to Willamette St	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-14	Gravity Main	Hardenbrook Ave	From Willamette St to Vallecito St	6	Lining		400	24	9,520	9,520	11,899	14,874	Immediate	10 Year	100%	0%	14,874	0
PI-15	Gravity Main	Olive St	From 290' w/o Givan St to Givan St	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-16	Gravity Main	ROW 130' e/o Ashby Rd	From 290' w/o Woodley Ave to 590' w/o Woodley Ave	8	Lining		325	37	12,106	12,106	15,133	18,916	Immediate	10 Year	100%	0%	18,916	0
PI-17	Gravity Main	ROW 150' e/o Ashby Rd	From 270' sw/o Wellington Pl to 340' nw/o Bloomsbury Ave	8	Lining		450	37	16,763	16,763	20,953	26,192	Immediate	10 Year	100%	0%	26,192	0
PI-18	Gravity Main	ROW 190' w/o Walton Ave	From 270' n/o Coeur D'Alene Ave to 120' s/o Coeur D'Alene Ave	10	Lining		375	51	19,013	19,013	23,767	29,708	Immediate	10 Year	100%	0%	29,708	0
PI-19	Gravity Main	ROW 180' nw/o Cascade Blvd	From Deer Creek Blvd to 200' n/o Pine Grove Ave	12	Lining		250	64	16,038	16,038	20,048	25,060	Immediate	10 Year	100%	0%	25,060	0
PI-20	Gravity Main	HWY-5	From Humboldt St to Poppy Ln	12	Lining		450	64	28,869	28,869	36,086	45,108	Immediate	10 Year	100%	0%	45,108	0
PI-21	Gravity Main	ROW 250' w/o Larkin Ave	From Poppy Ln to 290' s/o Poppy Ln	12	Lining		300	64	19,246	19,246	24,058	30,072	Immediate	10 Year	100%	0%	30,072	0
PI-22	Gravity Main	Greenwich Dr	From 400' n/o Autumn Harvest Way to Autumn Harvest Way	8	Lining		400	37	14,900	14,900	18,625	23,282	Immediate	10 Year	100%	0%	23,282	0
						Subtotal - Pipeline Infiltration Improvements				255,502	319,378	399,222					399,222	0

Total Pipeline Improvement Cost

	Existing Users	Future Users
Pipeline Capacity Improvements	5,093,855	9,824,480
Lift Station Improvements	192,000	1,712,630
Pipeline Condition Replacement Improvements	1,833,077	0
Pipeline Defect Repair Improvements	65,821	0
Pipeline Infiltration Improvements	399,222	0
Total Improvement Costs $19,121,086	**7,583,976**	**11,537,111**

Notes:
1. Costs are based on current ENR CCI of 10,386 for August 2016
2. Baseline construction costs plus 25% to account for unforeseen events and unknown conditions.
3. Estimated construction cost plus 25% to cover other costs including: engineering design, project administration (developer and City staff), construction management and inspection, and legal costs.
4. Lift Station 2 Baseline Construction Cost based on estimate received from City staff October 3, 2016. Cost sharing percentages based on capacity and required facility upgrades for existing users.

12/13/2016

CHAPTER 1 - INTRODUCTION

This chapter provides a brief background of the City of Shasta Lake's sanitary sewer system (also known as a wastewater collection system), the need for this master plan, and the objectives of the study. Abbreviations and definitions are also provided in this chapter.

1.1 BACKGROUND

The City of Shasta Lake located approximately 6 miles north of the city of Redding and 4 miles south of Lake Shasta (**Figure 1.1**). The City provides wastewater collection services to approximately 3,800 residential, commercial, industrial, and institutional accounts. The City owns, operates, and maintains the wastewater collection system, which consists of approximately 58 miles of gravity mains and force mains, with up to 21-inch pipe sizes, which convey the flow to the Shasta Lake Wastewater Treatment Plant (WWTP). The WWTP is designed to treat a dry weather flow of 1.3 million gallons per day (MGD).

In 2005, the City developed a Wastewater System Master Plan (2005 WWMP) that identified capacity deficiencies in the existing wastewater collection system and recommended improvements intended to mitigate deficiencies and serve future developments.

Recognizing the importance of planning, developing, and financing system facilities to provide reliable wastewater collection service to existing customers and for servicing anticipated growth, the City initiated the development of the 2016 WWMP.

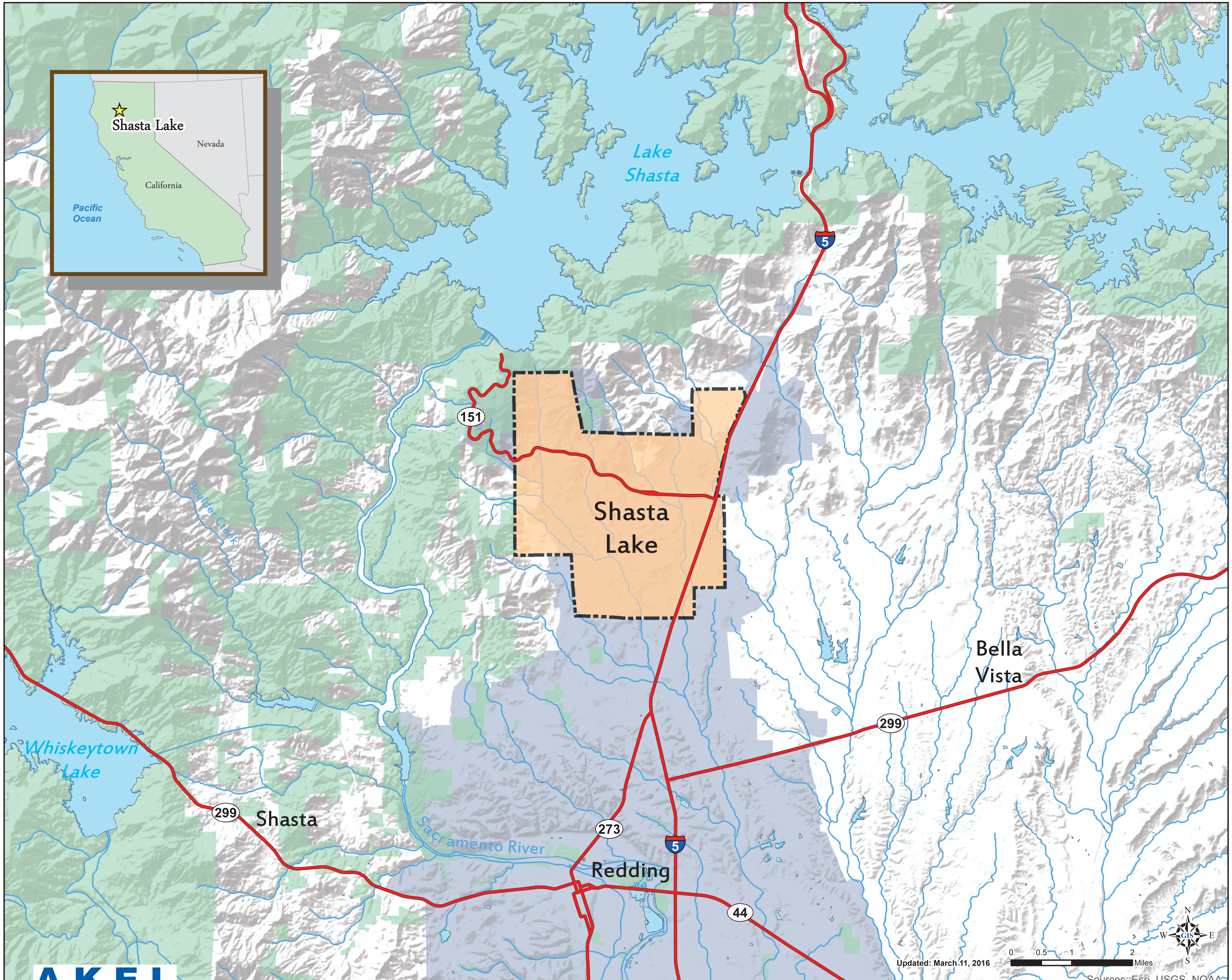
1.2 SCOPE OF WORK

In July 2015, the City selected Akel Engineering Group, Inc to complete this Wastewater Master Plan (WWMP). This 2016 WWMP is intended to serve as a tool for planning and phasing the construction of future wastewater collection system facilities for the City's projected planning horizon. The 2016 WWMP evaluates the City's wastewater system and recommends capacity improvements necessary to service the needs of existing users and for servicing the future growth of the City.

The General Plan planning horizon is greater than the projected planning horizon of this master plan. Should planning conditions change, and depending on their magnitude, adjustments to the master plan recommendations might be necessary.

The project included the following major tasks:

- Summarize the City's existing wastewater collection system facilities.
- Document growth planning assumptions and known future developments.
- Summarize the wastewater collection system performance criteria and design storm event.



Legend

- Major Highways
- City of Shasta Lake
- Urbanized Area
- Protected Open Space
- Rivers/Streams
- Waterbodies

Figure 1.1
Regional Location Map

Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

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- Project future wastewater flows.
- Develop and calibrate a new hydraulic model based on the City's Geographic Information Systems (GIS).
- Evaluate the adequacy of capacity for the wastewater collection system facilities to meet existing and projected peak dry weather flows and peak wet weather flows.
- Recommend a capital improvement program (CIP) with an opinion of probable construction costs.
- Perform a capacity allocation analysis for cost sharing purposes between existing users and future growth.
- Develop a Wastewater Master Plan Report.

1.3 PREVIOUS MASTER PLANS

The City's most recent wastewater master plan was completed in 2005. This master plan included evaluation of servicing growth to the planned area, evaluating existing wastewater flows and projected future flows, and recommending phased improvements to the wastewater collection system for a horizon year of 2020. Additionally, the 2005 WWMP included the development of the hydraulic model, which was used for evaluating the wastewater collection system. Improvements were recommended for servicing existing and future growth areas, and a corresponding Capital Improvement Program was developed to quantify the corresponding costs.

The 2005 WWMP identified multiple trunk sewer mains requiring parallel or replacement improvements to reduce I&I into the wastewater collection system. In an effort to maximize available funds, the City prioritized the recommended improvements based on areas with the most critical infiltration and inflows into the wastewater system. Following the completion of an environmental review of the project in 2006, the City submitted an application for funding from the Community Development Block Grant (CDBG) program. The City received $2 million in funding in 2008, which was used to complete the identified I&I improvements. These improvements helped to reduce the amount of I&I into the wastewater collection system.

1.4 RELEVANT REPORTS

The City has completed several special studies intended to evaluate localized growth. These reports were referenced and used during this capacity analysis. The following lists relevant reports that were used in the completion of this master plan, as well as a brief description of each document:

- Wastewater System Master Plan, June 2005 (2005 WWMP). This report documents the planning and performance criteria, evaluates the wastewater collection system, recommends improvements, and provides an estimate of costs.

- Water and Wastewater Utility Rate Update, April 2014 (2014 Rate Study). This report summarizes the City's water and wastewater utility revenues and expenditures, documents transfers to the capital improvement fund, and allocates funds for capital projects.

1.5 REPORT ORGANIZATION

The Wastewater Master Plan report contains the following chapters:

Executive Summary. This chapter provides a brief overview of this master plan, and includes key factors leading to the findings and the overall CIP. This includes the capacity evaluation, as well as the condition assessment evaluation of the wastewater system.

Chapter 1 – Introduction. This chapter provides a brief background of the City of Shasta Lake's wastewater collection system, the need for this master plan, and the objectives of the study. Abbreviations and definitions are also provided in this chapter.

Chapter 2 – Planning Area Characteristics. This chapter presents a discussion of the planning area characteristics for this master plan including a study area description; service areas land use; and population for the City of Shasta Lake.

Chapter 3 – System Performance and Design Criteria. This chapter presents the City's performance and design criteria, which were used in this master plan for evaluating the adequacy of capacity for the existing wastewater collection system and for sizing improvements required to mitigate deficiencies and to accommodate future growth. The design criteria includes: capacity requirements for the wastewater facilities, flow peaking factors, and minimum slope requirements.

Chapter 4 – Existing Wastewater Collection Facilities. This chapter provides a description of the City's existing wastewater collection system facilities including gravity trunks, force mains, lift stations, and wastewater collection basins. The chapter also includes a brief description of the Shasta Lake Wastewater Treatment Plant.

Chapter 5 – Wastewater Flows. This chapter summarizes historical wastewater flows experienced at the Shasta Lake WWTP and defines flow terminologies relevant to this evaluation. This chapter discusses the wastewater flow distribution within the 6 basins, and identifies the design flows used in the hydraulic modeling effort and capacity evaluation. The design flows include the existing condition (existing customers) and the projected ultimate buildout scenario.

Chapter 6 – Hydraulic Model Development. This chapter describes the development and calibration of the City's wastewater collection system hydraulic model. Hydraulic network analysis has become an effectively powerful tool in all aspects of wastewater collection system planning, design, operation, management, and system reliability analysis. The City's hydraulic model was used to evaluate the capacity adequacy of the existing system and to plan its expansion to service anticipated future growth.

Chapter 7 – Evaluation and Proposed Improvements. This section presents a summary of the wastewater facility capacity evaluation during peak dry weather flows and peak wet weather flows for the existing and buildout flows. The recommended wastewater collection system improvements needed to mitigate capacity deficiencies are also discussed in this chapter.

Chapter 8 – Capital Improvement Program. This chapter provides a summary of the recommended Capital Improvement Program (CIP) for the City of Shasta Lake's wastewater collection system. The program is based on the evaluation of the City's wastewater collection system, and on the recommended projects described in the previous chapters. The CIP has been prepared to assist the City in planning and constructing the collection system improvements through the ultimate buildout scenario. This chapter also presents the cost criteria and methodologies for developing the capacity improvement costs.

1.6 ACKNOWLEDGEMENTS

Obtaining the necessary information to successfully complete the analysis presented in this report, and developing the long term strategy for mitigating the existing system deficiencies and for accommodating future growth, was accomplished with the strong commitment and very active input from dedicated team members including:

- Jeff Tedder, City Engineer.
- Jose Castro, Public Works Supervisor.
- Tom Chism, Wastewater Treatment Superintendent.
- Debbie Israel, Senior Planner.
- Mark Juarez, Engineering Technician.

1.7 UNIT CONVERSIONS AND ABBREVIATIONS

Engineering units were used in reporting flow rates and volumes pertaining to the design and operation of various components of the wastewater system. In some cases, different sets of units were used to describe the same parameter where it was necessary to report values in smaller or larger quantities. Values reported in one set of units can be converted to another set of units by applying a multiplication factor. A list of multiplication factors for units used in this report are shown on **Table 1.1**.

Various abbreviations and acronyms were also used in this report to represent relevant wastewater system terminologies and engineering units. A list of abbreviations and acronyms is included in **Table 1.2**.

1.8 GEOGRAPHIC INFORMATION SYSTEMS

This master planning effort made extensive use of Geographic Information Systems (GIS) technology, for efficiently completing the following tasks:

- Developing the physical characteristics of the hydraulic model (gravity mains, force mains, and lift stations).

Table 1.1 Unit Conversions
Wastewater Master Plan
City of Shasta Lake

Volume Unit Calculations		
To Convert From:	**To:**	**Multiply by:**
acre feet	gallons	325,857
acre feet	cubic feet	43,560
acre feet	million gallons	0.3259
cubic feet	gallons	7.481
cubic feet	acre feet	2.296×10^{-5}
cubic feet	million gallons	7.481×10^{-6}
gallons	cubic feet	0.1337
gallons	acre feet	3.069×10^{-6}
gallons	million gallons	1×10^{-6}
million gallons	gallons	1,000,000
million gallons	cubic feet	133,672
million gallons	acre feet	3.069

Flow Rate Calculations		
To Convert From:	**To:**	**Multiply By:**
ac-ft/yr	mgd	8.93×10^{-4}
ac-ft/yr	cfs	1.381×10^{-3}
ac-ft/yr	gpm	0.621
ac-ft/yr	gpd	892.7
cfs	mgd	0.646
cfs	gpm	448.8
cfs	ac-ft/yr	724
cfs	gpd	646300
gpd	mgd	1×10^{-6}
gpd	cfs	1.547×10^{-6}
gpd	gpm	6.944×10^{-4}
gpd	ac-ft/yr	1.12×10^{-3}
gpm	mgd	1.44×10^{-3}
gpm	cfs	2.228×10^{-3}
gpm	ac-ft/yr	1.61
gpm	gpd	1,440
mgd	cfs	1.547
mgd	gpm	694.4
mgd	ac-ft/yr	1,120
mgd	gpd	1,000,000

8/25/2016

Table 1.2 Abbreviations and Acronyms
Wastewater Master Plan
City of Shasta Lake

Abbreviation	Expansion	Abbreviation	Expansion
2005 WWMP	2005 Wastewater System Master Plan	gpd	Gallons per Day
2016 WWMP	2016 Wastewater Master Plan	gpm	Gallons per Minute
10yr-24hr	10-Year 24-Hour	HE	Household equivalent
AACE	Association for the Advancement of Cost Engineering	HGL	Hydraulic Grade Line
ADWF	Average Dry Weather Flow	in/hr	Inch per Hour
AAF	Annual Average Flow	I&I	Infiltration and Inflow
Akel	Akel Engineering Group, Inc.	LF	Linear Feet
AWWF	Average Wet Weather Flow	LS	Lift Station
CCI	Construct Cost Index	MDDWF	Maximum Day Dry Weather Flow
CCTV	Closed Circuit Television	MDWWF	Maximum Day Wet Weather Flow
CDP	Census Designated Place	MGD	Million Gallons per Day
CIP	Capital Improvement Program	MMDWF	Maximum Month Dry Weather Flow
City	City of Shasta Lake	MMWWF	Maximum Month Wet Weather Flow
CIPP	Cured in Place Pipe	NASSCO	National Association of Sewer Service Compaines
DDF	Depth Duration Frequency	NOAA	National Oceanic and Atmospheric Administration
d/D	depth of flow to pipe diameter	PDWF	Peak Dry Weather Flow
ENR	Engineering News Record	PWWF	Peak Wet Weather Flow
ft	Feet	PACP	Pipeline Assessment and Certification Program
fps	Feet per Second	ROW	Right of Way
FY	Fiscal Year	VCP	Vitrified Clay Pipe
GIS	Geographic Information Systems	WWTP	Wastewater Treatment Plant
gpdc	Gallons per day per capita		

- Allocating existing wastewater loads, as calculated using the developed wastewater unit factors.
- Calculating and allocating future wastewater loads, based on the future developments land use.
- Extracting ground elevations along the gravity and force mains from available contour maps.
- Generating maps and exhibits used in this master plan.

CHAPTER 2 - PLANNING AREA CHARACTERISTICS

This chapter presents a discussion of the planning area characteristics for this master plan and includes a study area description, service area land use, and population for the City of Shasta Lake.

2.1 STUDY AREA DESCRIPTION

The City of Shasta Lake is located in Shasta County in the northern part of California known as Sacramento Valley, approximately 6 miles north of the city of Redding and 150 miles north of the city of Sacramento. Interstate 5 runs in a northeast-southwest direction along the east side of the City. The city limits currently encompass 10.9 square miles, with an estimated population of 10,541 residents according to California Department of Finance (DOF) population estimates.

A developed area to the west of the City, known as Summit City, is part of the City's water service area but not part of the City's sewer service area. For the purpose of this master plan, the sewer service area population is calculated as the City population less the estimated Summit City population.

The City is generally bound to the north by United States Forest Service Land, to the east by Lake Boulevard, to the west by Interstate 5, and to the south by the city of Redding. There are several small creeks that traverse central and western portions of City. The topography consists of southern Cascade foothills, with elevations ranging from 670 feet in the south to approximately 1,000 feet in the northwest. **Figure 2.1** displays the city limits, which represent the planning area of the City's General Plan.

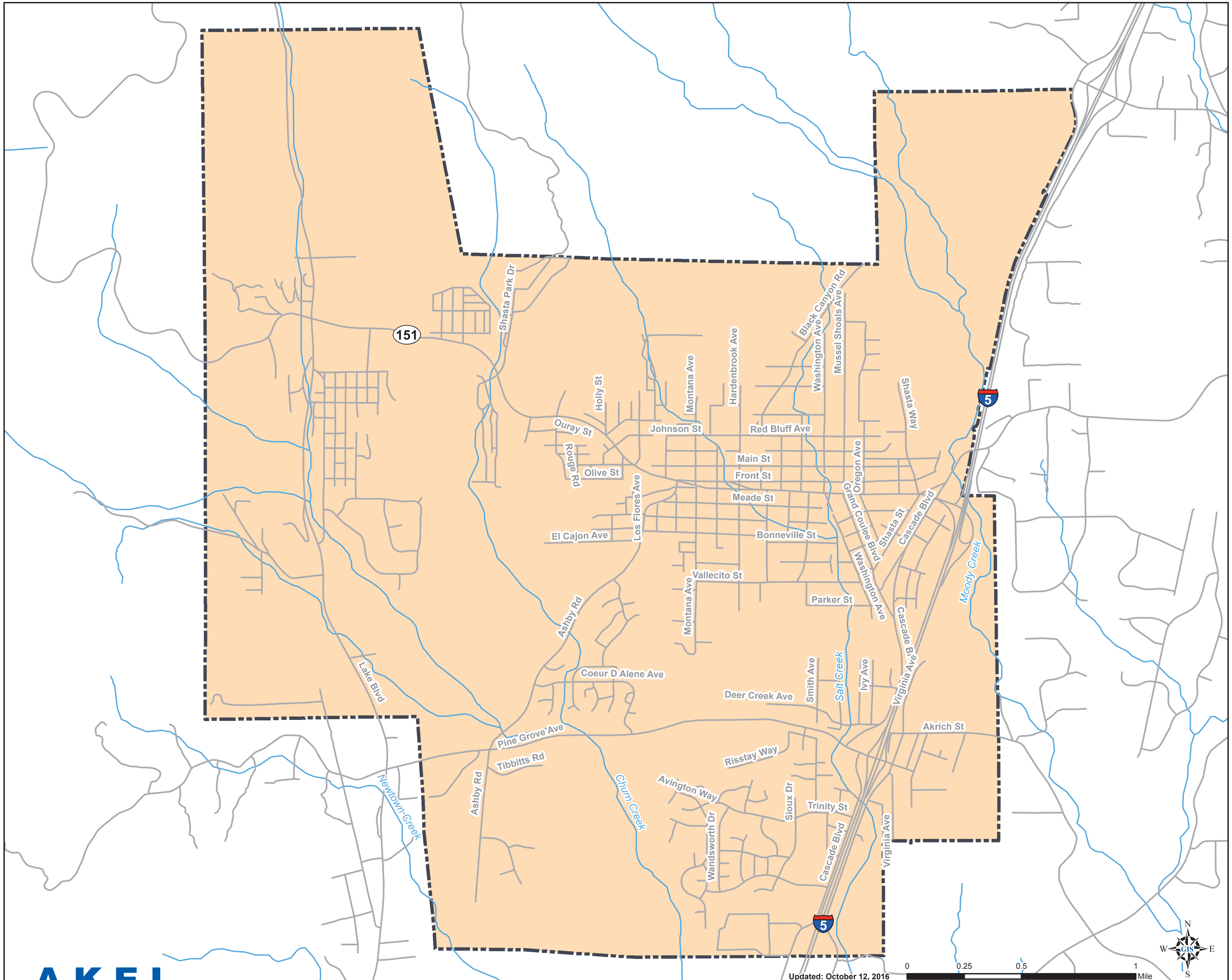
The City operates and maintains a wastewater collection system that covers the majority of the area within the City Limits east of Shasta Park Drive. Currently, the wastewater flows are conveyed to the City's WWTP.

2.2 SEWER SERVICE AREAS AND LAND USE

The City of Shasta Lake's wastewater collection system services residential and non-residential lands within the City limits, as summarized on **Table 2.1**. This service area includes:

- 1,564 net acres of developed lands inside the service area.
- 462 net acres of undeveloped lands inside the service area.

The existing land use statistics were based on land use information provided by City staff, as shown on **Figure 2.2**. City staff provided the updated County of Shasta (County) parcel map, which was used as part of this analysis.



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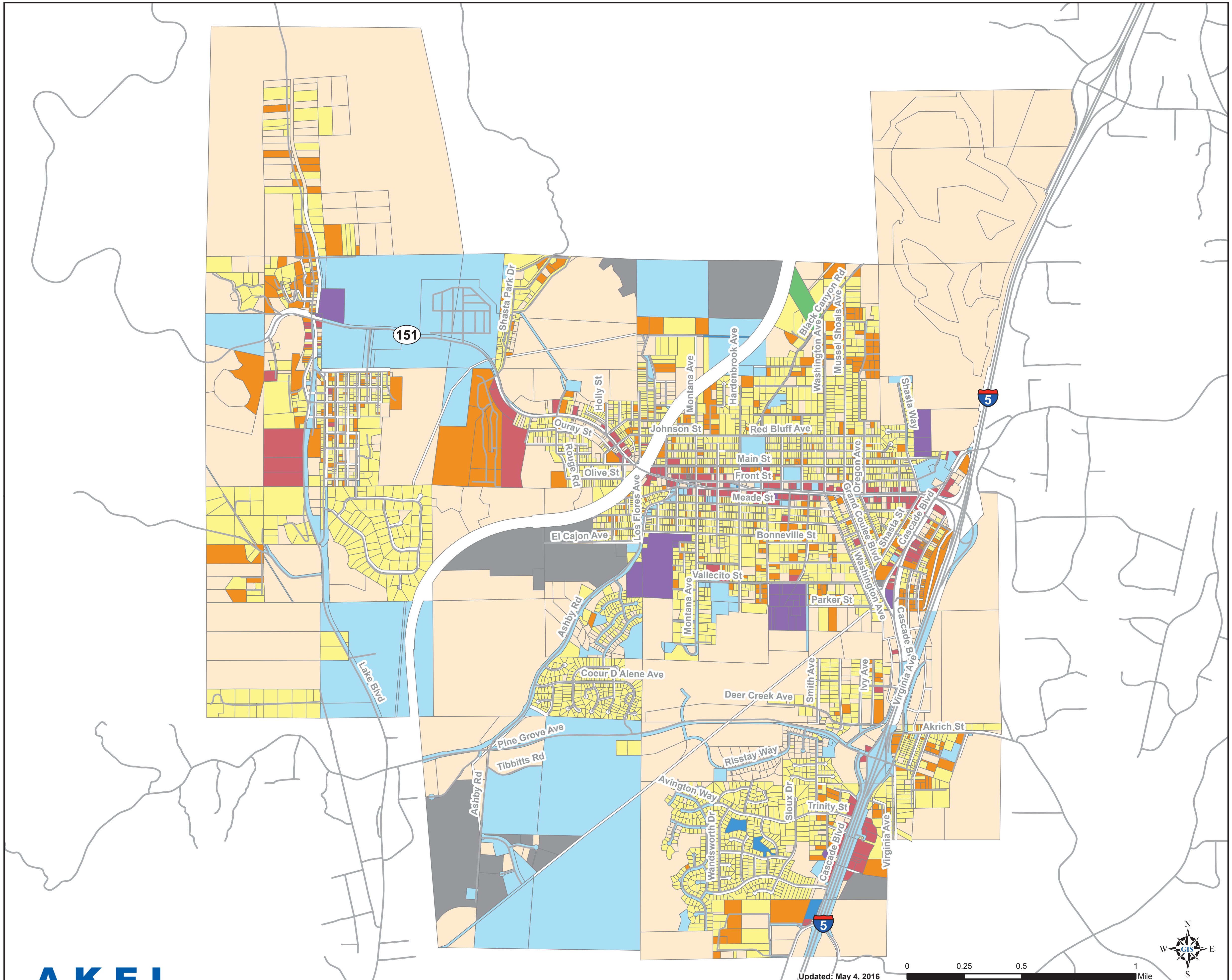
Legend

- City Limits
- Street Centerlines
- Rivers/Streams

Figure 2.1
Planning Area

Wastewater Master Plan
City of Shasta Lake

CITY OF SHASTA LAKE



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Existing Land Use

- Agricultural
- Commercial
- Government
- Industrial
- Institutional
- Public Facility
- Single Family Residential
- Multi-Family Residential
- Vacant
- Street Centerlines

Figure 2.2
Existing Land Use

Wastewater Master Plan
City of Shasta Lake

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Table 2.1 General Plan Land Use

Wastewater Master Plan
City of Shasta Lake

Land Use Classification[1]	Existing Service Area			Outside Service Area	
	Developed (net acre)	Vacant: Within Service Area (net acre)	Vacant: Within Planning Focus Subareas (net acre)	Developed (net acre)	Vacant (net acre)
1	2	3	4	5	6
Residential					
Rural Residential A	1	0	0	95	182
Rural Residential B	9	0	0	91	492
Suburban Residential	208	74	0	403	375
Urban Residential	790	193	44	98	161
Urban Residential High A	3	2	1	0	0
Urban Residential High B	80	8	8	0	0
Subtotal	1,090	277	53	686	1,210
Non-Residential					
Mixed Use	13	50	50	18	681
Village Mixed Use	24	10	10	7	2
Commercial	55	52	52	0	8
Industrial Light	1	18	18	0	0
Industrial	72	18	0	0	448
Special Users[2,3]	122	0	0	0	0
Public Facilities	64	37	8	74	180
Subtotal	351	185	138	99	1,319
Other (Non-flow generating)					
Community Park	69	-	-	33	-
Open Space	8	-	-	24	-
Federal Government	9	-	-	163	-
Freeway	5	-	-	3	-
Railway	0	-	-	0	-
Easement	1	-	-	11	-
ROW	31	-	-	49	-
Subtotal	123	0	0	281	0
Total					
	1,564	462	191	1,066	2,529

Notes:

7/15/2016

1. Source: General Plan Land Use shapefile received from Dynamic Planning staff July 1, 2016.
2. Top 3 industrial water accounts (Knauf Insulation and Sierra Pacific Sawmill) as extracted from 2014 Water Billing Records.
3. Developed acres estimated based on aerial imagery.

The County map included developed and undeveloped areas, which were classified into the following subtypes:

- Net Area. Net areas are typically built out, and exclude street and other associated right of ways.
- Gross Area. Gross areas are typically large undeveloped parcels, which may be subdivided in future developments. Part of these areas will include street and other right of ways.

For the purposes of this master plan, net areas were used in the quantification of wastewater flows, as they represent the total acreage that contributes wastewater flow to the collection system. In order to convert the areas that were identified as gross areas to net areas, the following reduction factors were applied:

- Single Family Residential land use types: 1 gross acre = 0.80 net acre
- Multi-Family Residential/Mixed Use land use types: 1 gross acre = 0.85 net acre
- Commercial/Industrial land use types: 1 gross acre = 0.90 net acre

The City's General Plan anticipates approximately 5,622 net acres of residential and non-residential development at ultimate buildout. The land use designations utilized in this master plan are consistent with the Land Use Element of the City's General Plan, and as received from the City's planning division and shown on **Figure 2.3**.

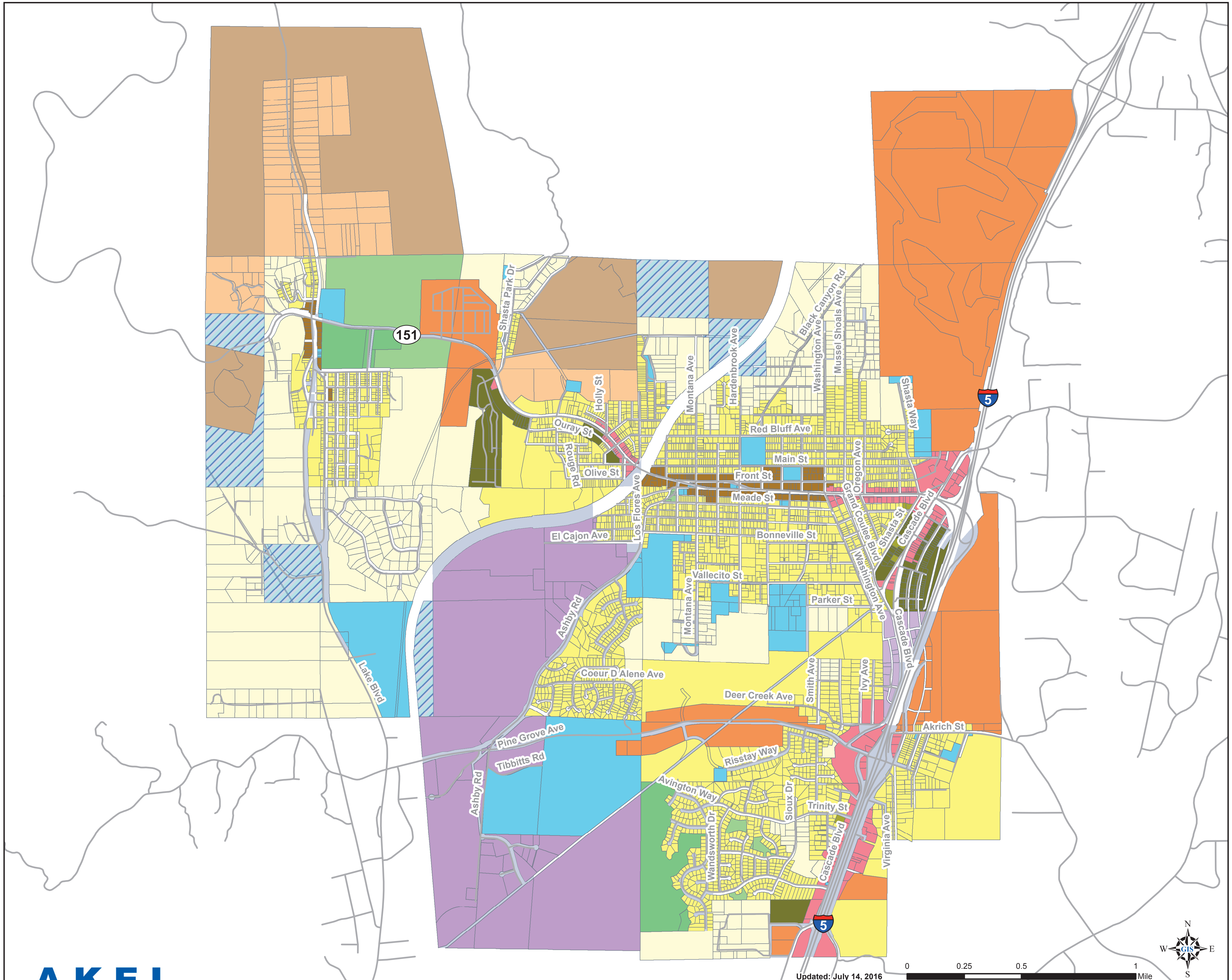
City staff have indicated that buildout of the General Plan is not anticipated within the planning horizon of this master plan based on historical growth rates. As such, the projected sewer service area was planned based on City staff knowledge of anticipated development, which consists of approximately 90 net acres of residential development and 575 net acres of mixed use and non-residential development throughout the duration of the master plan horizon.

2.3 FOCUS AREAS

The City's General Plan has identified four individual areas within the planning boundary that are itemized for specific growth projections. These four areas, designated as Focus Areas, are shown on **Figure 2.4** and described in the following.

2.3.1 Focus Area 1

Focus Area 1 is composed of 8 planning sub-areas totaling approximately 334 net acres in the eastern and central portions of the City. The area has two distinct sections: one extending west from Interstate 5 to the railroad tracks and bound to the north by Main Street and to the south by Meade Street; and the second extending south from Dyke Street to Fell Street, adjacent to Interstate 5. The General Plan land use for this area generally consists of mixed use, commercial, and urban residential designations. Development projections estimate approximately 89 new residential dwelling units, and approximately 87,520 square feet of new commercial space within Focus Area 1.



Legend

General Plan Land Use

- Suburban Residential
- Urban Residential
- Urban Residential High A
- Urban Residential High B
- Rural Residential A
- Rural Residential B
- Commercial
- Mixed Use
- Village Mixed Use
- Industrial
- Industrial Light
- Community Park
- Federal Government
- Public Facilities
- Open Space
- ROW
- Street Centerlines

Figure 2.3
2035 General Plan Land Use
Wastewater Master Plan
City of Shasta Lake

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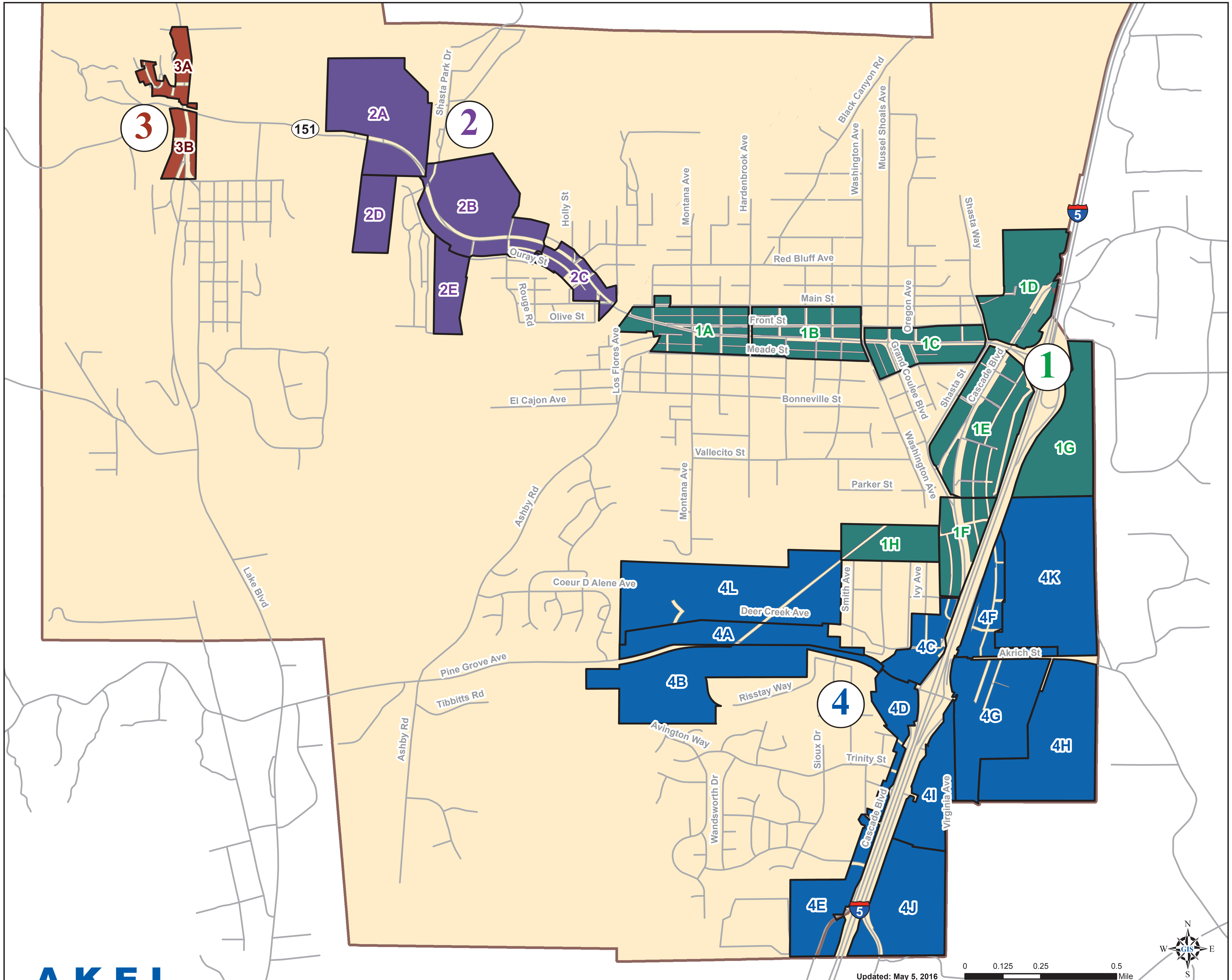

Figure 2.4
Growth Focus Areas
Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

Updated: May 5, 2016

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2.3.2 Focus Area 2

Focus Area 2 is composed of 5 planning sub-areas in the northwest portion of the City that total approximately 187 net acres. This focus area is generally bound by the railroad tracks to the east, and follows Shasta Dam Boulevard westward to the extents of the historic Toyon property. The General Plan land use for this area generally consists of mixed use, urban residential, and small areas of commercial and rural residential designations. There are 71 new residential units, and approximately 20,475 square feet of new commercial space.

2.3.3 Focus Area 3

Focus Area 3 is composed of 2 planning sub-areas in the Summit City area, and totals approximately 29 net acres. The area is located generally in the vicinity of the Lake Boulevard and Shasta Dam Boulevard intersection. The General Plan land use for this area generally consists of mixed use and urban residential designations. There are 27 new residential units and 5,200 square feet of commercial space allocated for development in this focus area.

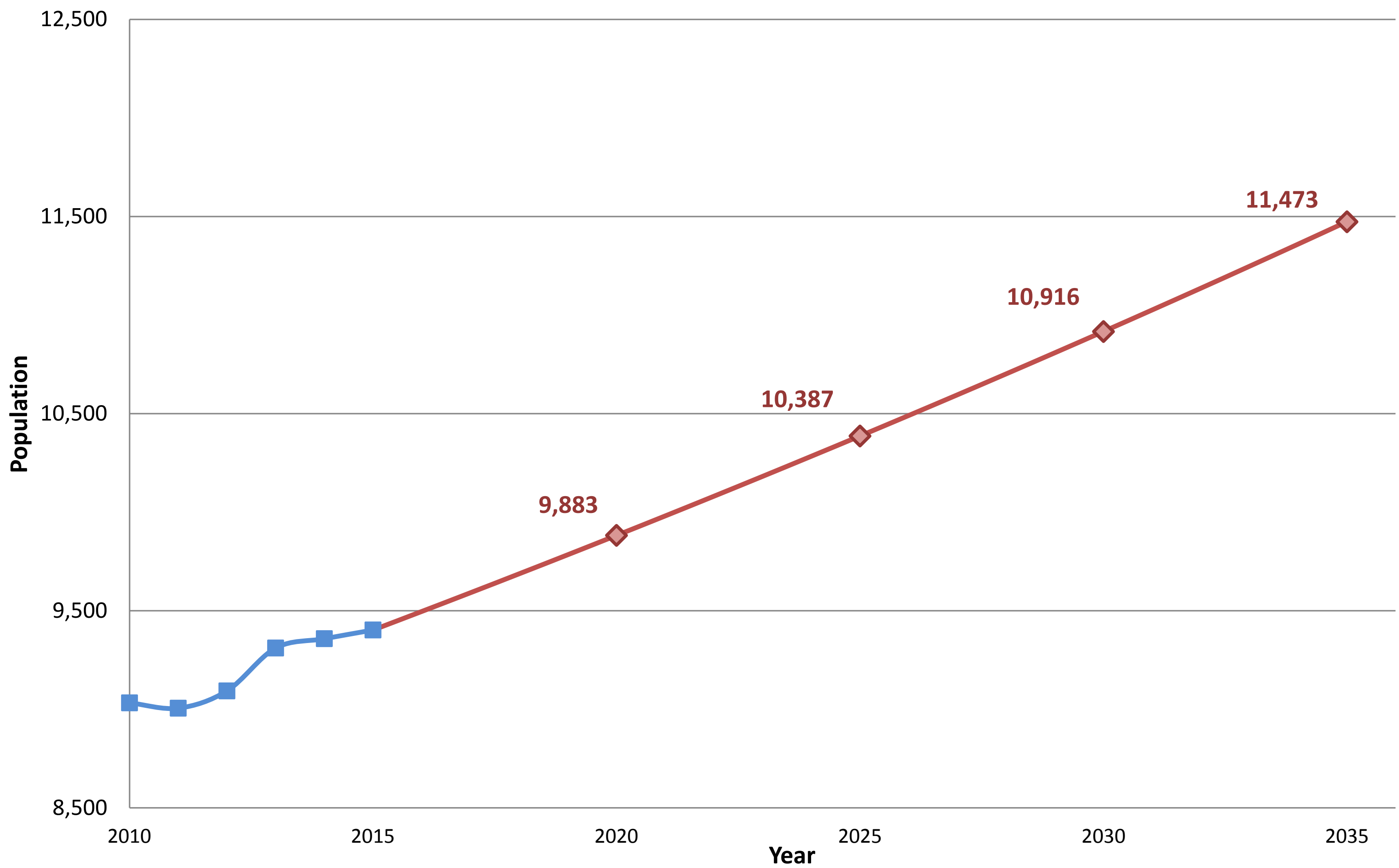
2.3.4 Focus Area 4

Focus Area 4 is composed of 12 planning sub-areas in the southeast portion of the City and totals approximately 638 net acres. The area is generally located along the Interstate 5 corridor from Parker Street to Crooked Oak Lane, and the Pine Grove Avenue corridor from Redwing Lane to the wastewater treatment plant. The General Plan land use for this area generally consists of mixed use, commercial, and urban residential designations. This focus area is the largest planned development area with approximately 156 residential units and 32,500 square feet of commercial space.

2.4 HISTORICAL AND PROJECTED SERVICE AREA POPULATION

Projected population was developed for the service area, and is based on growth projections provided by City planning staff. It should be noted that the General Plan land use area incorporates opportunities for growth in excess of recent and historical development trends. As such, areas of growth in the near term were identified by planning and engineering staff. Though historical populations were used in understanding the domestic wastewater flow behaviors and trends, population forecasts are presented for informational purposes only.

The City's historical and projected population data are presented in **Figure 2.5**, and represent the service area population, excluding the area to the west of the City known as Summit City. This area is generally located along Lake Boulevard and Shasta Dam Boulevard. Currently there are no plans to include Summit City as part of the wastewater collection system, and therefore, the population estimates reflected in this Master Plan exclude this area. The historical information was extracted from the previous master plan and California Department of Finance documents. **Table 2.2** documents the historical population from 2010 to 2015 and the projected population is shown linearly through 2035. City staff project growth to remain constant through 2035 at 1.0 percent, resulting in a sewer service area population of approximately 11,473.



LEGEND

Projected Population

Historical Population

Notes:

1. Projected population excludes Summit City and assumes an annual growth rate of 1.0%.
2. Excluded Summit City population estimated based on approximate number of dwelling units and 2.6 persons per household.

September 6, 2016

Figure 2.5

Historical and Projected Population

Wastewater Master Plan

City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

Table 2.2 Historical and Projected Population
Wastewater Master Plan
City of Shasta Lake

Year	Population[1]	Percent Growth (%)
Historical		
2010	9,033	-
2011	9,006	-0.3%
2012	9,094	1.0%
2013	9,311	2.4%
2014	9,359	0.5%
2015	9,403	0.5%
Projected		
2016	9,497	1.0%
2017	9,592	1.0%
2018	9,688	1.0%
2019	9,785	1.0%
2020	9,883	1.0%
2021	9,981	1.0%
2022	10,081	1.0%
2023	10,182	1.0%
2024	10,284	1.0%
2025	10,387	1.0%
2026	10,491	1.0%
2027	10,595	1.0%
2028	10,701	1.0%
2029	10,808	1.0%
2030	10,916	1.0%
2031	11,026	1.0%
2032	11,136	1.0%
2033	11,247	1.0%
2034	11,360	1.0%
2035	**11,473**	1.0%

Note: 9/6/2016

1. Historical Populations per California Department of Finance estimates, excluding estimated Summit City Population.
2. Projected population excludes Summit City and assumes an annual growth rate of 1.0%.
3. Projected ADWF calculated assuming a per-capita flow of approximately 67 gpcd.

CHAPTER 3 - SYSTEM PERFORMANCE AND DESIGN CRITERIA

This chapter presents the City's performance and design criteria, which were used in this master plan for evaluating the adequacy of capacity for the existing wastewater collection system and for sizing improvements required to mitigate deficiencies and to accommodate future growth. The design criteria includes: capacity requirements for the wastewater facilities, flow peaking factors, and minimum slope requirements.

3.1 HYDRAULIC CAPACITY CRITERIA

In addition to applying the City design standards for evaluating hydraulic capacities; this master plan included dynamic hydraulic modeling. The dynamic modeling was a critical and essential element in identifying surcharge conditions resulting from downstream bottlenecks in the gravity sewers.

3.1.1 Gravity Sewers

Gravity sewer capacities depend on several factors including: material and roughness of the pipe, the limiting velocity and slope, and the maximum allowable depth of flow. The hydraulic modeling software used for evaluating the capacity adequacy of the Shasta Lake wastewater collection system, InfoSewer by Innovyze Inc., utilizes the Muskingum-Cunge technique for analyzing unsteady open channel flow. Pressurized pipe in the hydraulic model is assumed to flow full for the entirety of the pipe, so as to utilize the energy equation.

Manning's Equation for Pipe Capacity

The Continuity equation and the Manning equation for steady-state flow are used for calculating pipe capacities in open channel flow. Open channel flow can consist of either open conduits or, in the case of gravity sewers, partially full closed conduits. Gravity full flow occurs when the conduit is flowing full but has not reached a pressure condition.

- Continuity Equation: $Q = V A$

  Where:
  Q = peak flow, in cubic feet per second (cfs)
  V = velocity, in feet per second (fps)
  A = cross-sectional area of pipe, in square feet (sq. ft.)

- Manning Equation: $V = (1.486 R^{2/3} S^{1/2})/n$

  Where:
  V = velocity, fps
  n = Manning's roughness coefficient
  R = hydraulic radius (area divided by wetted perimeter), ft
  S = slope of pipe, in feet per foot

St. Venant's Equation for Pipe Capacity

Dynamic modeling facilitates the analysis of unsteady and non-uniform flows (dynamic flows) within a sewer system. Some hydraulic modeling programs have the ability to analyze these types of flows using the St. Venant equation, which take into account unsteady and non-uniform conditions that occur over changes in time and cross-section within system pipes.

The St. Venant equation is a set of two equations, a continuity equation and a dynamic equation, that are used to analyze dynamic flows within a system. The first equation, the continuity equation, relates the continuity of flow mass within the system pipes in terms of: (A) the change in the cross-sectional area of flow at a point over time and (B) The change of flow over the distance of piping in the system. The continuity equation is provided as follows:

- Continuity Equation: $$\underbrace{\frac{\partial A}{\partial t}}_{(A)} + \underbrace{\frac{\partial Q}{\partial x}}_{(B)} = 0$$

  Where:
  t = time
  x = distance along the longitudinal direction of the channel
  Q = discharge flow
  A = flow cross-sectional area perpendicular to the x directional axis

The second equation, the dynamic equation, relates changes in flow to fluid momentum in the system using: (A) Changes in acceleration at a point over time, (B) Changes in convective flow acceleration, (C) Changes in momentum due to fluid pressure at a given point, (D) Changes in momentum from the friction slope of the pipe and (E) Fluid momentum provided by gravitational forces. The dynamic equation is provided as follows:

- Dynamic Equation: $$\underbrace{\frac{\partial Q}{\partial t}}_{(A)} + \underbrace{\frac{\partial}{\partial t}\left(\beta \frac{Q^2}{A}\right)}_{(B)} + \underbrace{gA\frac{\partial y}{\partial x}}_{(C)} + \underbrace{gAS_f}_{(D)} - \underbrace{gAS_o}_{(E)} = 0$$

  Where:
  t = time
  x = distance along the longitudinal direction of the channel
  Q = discharge flow
  A = flow cross-sectional area perpendicular to the x directional axis
  y = flow depth measured from the channel bottom and normal to the x directional axis
  S_f = friction slope
  S_o = channel slope
  β = momentum
  g = gravitational acceleration

Use of this method of analysis provides a more accurate and precise analysis of flow conditions within the system compared to steady state flow analysis methods. It must be noted that two assumptions are made for use of St. Venant equations in the modeling software. First, flow is one dimensional. This means it is only necessary to consider velocities in the downstream direction and not in the transverse or vertical directions. Second, the flow is gradually varied. This means the vertical pressure distribution increases linearly with depth within the pipe.

It should be noted that the InfoSewer model utilizes the Muskingum-Cunge technique, which excludes computation of the local acceleration factor, Item (A) in the dynamic equation on the previous page.

Manning's Roughness Coefficient (n)

The Manning roughness coefficient 'n' is a friction coefficient that is used in the Manning formula for flow calculation in open channel flow. In sewer systems, the coefficient can vary between 0.009 and 0.017 depending on pipe material, size of pipe, depth of flow, root intrusion, smoothness of joints, and other factors.

For the purpose of this evaluation, and in accordance with City standards, an "n" value of 0.013 was used for both existing and proposed gravity sewer pipes unless directed otherwise by City staff based on pipe structural condition. This "n" value is an acceptable practice in planning studies.

Partial Flow Criteria (d/D)

Partial flow in gravity sewers is expressed as a depth of flow to pipe diameter ratio (d/D). For circular gravity conduits, the highest capacity is generally reached at 92 percent of the full height of the pipe (d/D ratio of 0.92). This is due to the additional wetted perimeter and increased friction of a gravity pipe.

When designing sewer pipelines, it is common practice to use variable flow depth criteria that allow higher safety factors in larger sizes. Thus, design d/D ratios may range between 0.5 and 0.92, with the lower values used for smaller pipes. The smaller pipes may experience flow peaks greater than planned or may experience blockages from debris.

The City's design standards pertaining to the d/D criteria are summarized in **Table 3.1**.

During peak dry weather flows (PDWF), the maximum allowable d/D ratio for proposed pipes of all sizes is 0.75. The maximum allowable d/D ratio for all existing pipes (all diameters) is 0.92. The criterion for existing pipes is relaxed in order to maximize the use of the existing pipes before costly pipes improvements are required.

During peak wet weather flows (PWWF), to avoid premature or unnecessary trunk line replacements, the capacity analysis allowed the d/D ratio to exceed the dry weather flow criteria and surcharge. This condition is evaluated using the dynamic hydraulic model and the criteria listed on **Table 3.1**, which stipulates that the hydraulic grade line (HGL), even during a surcharged condition, should be at least three foot below the manhole rim elevation.

Table 3.1 Performance and Design Criteria
Wastewater Master Plan
City of Shasta Lake

Pipeline Criteria		
Peak Dry Weather Flow Criteria		
Diameter (in)	**Maximum Allowable d/D**	
	Existing Trunks	**Proposed Trunks**
Any Pipe Size	**0.92**	**0.75**
Peak Wet Weather Flow Criteria		
Hydraulic Grade Line (HGL) should be **3 feet** below the manhole rim		
Average Dry Weather Flow HE Criteria		
1 HE = 170 gpd		
Dry Weather Flow Peaking Factor		
Peak Dry Weather Flow = **1.7** x Average Dry Weather Flow		
Lift Station Capacity		
Lift Station capacity shall be sized to meet PWWF with largest unit out of service		

Pipe Size (in)	**Minimum Grade** (ft/ft)	**Capacity** (n = 0.013) (mgd)	(cfs)
8	0.0040	0.50	0.77
10	0.0030	0.78	1.20
12	0.0025	1.15	1.79
15	0.0014	1.59	2.45
18	0.0011	2.28	3.53
21	0.0009	3.11	4.81
24	0.0008	4.06	6.28
27	0.0007	5.14	7.95
30	0.0006	6.34	9.81
33	0.0005	7.67	11.88

9/10/2016

Minimum Pipe Sizes and Design Velocities

In order to minimize the settlement of sewage solids, it is standard practice in the design of gravity sewers to specify that a minimum velocity of 2 feet per second (fps) be maintained when the pipeline is half-full. At this velocity, the sewer flow will typically result with self-cleaning of the pipe.

Due to the hydraulics of a circular conduit, velocity of half-full flows approaches the velocity of nearly full flows. **Table 3.1** lists the minimum slopes, varying by pipe size, in accordance with the City's design standards. The design standards also specify minimum pipe sizes, depending on the peak dry weather flows, as shown on **Table 3.1**.

Changes in Pipe Size

When a smaller gravity sewer pipe joins a larger pipe, the invert of the larger pipe is generally to maintain the same energy gradient. One of the methods used to approximate this condition includes placing the 80 percent depth point (d/D at 0.8) from both sewers at the same elevation. For master planning purposes, and in the absence of known field data, sewer crowns were matched at the manholes.

3.1.2 Force Mains and Lift Stations

The Hazen-Williams formula is commonly used for the design of force mains as follows:

- Hazen Williams Velocity Equation: $V = 1.32\ C\ R^{0.63}\ S^{0.54}$

Where:
V = mean velocity, fps
C = roughness coefficient
R = hydraulic radius, ft
S = slope of the energy grade line, ft/ft

The value of the Hazen-Williams 'C' varies and depends on the pipe material and is also influenced by the type of construction and pipe age. A 'C' value of 110 was used in this analysis.

The minimum recommended velocity in force mains is at 2 feet per second. The economical pumping velocity in force mains ranges between 3 and 5 fps. A maximum desired velocity is typically around 7 fps and a maximum not-to-exceed velocity is at 10 fps.

The capacities of pump stations are evaluated and designed to meet the peak wet weather flows with one standby pump having a capacity equal to the largest operating unit. The standby pump provides a safety factor in case the duty pump malfunctions during operations and allows for maintenance.

3.2 DRY WEATHER FLOW CRITERIA

Wastewater unit flow factors are coefficients commonly used in planning level analysis to estimate future average daily wastewater flows for areas with predetermined land uses. The unit factors are multiplied by the number of dwelling units or gross acreages for residential categories, and by the gross acreages for non-residential categories, to yield the average daily wastewater flow projections.

3.2.1 Unit Flow Factors Methodology

Wastewater unit factors are developed by using water consumption records and applying a return to sewer ratio for each land use to estimate wastewater flow coefficients. There are several methods for developing the unit factors. This analysis relied on the use of the City's 2014 water billing records, and 2014 wastewater treatment plant flows.

3.2.2 Average Daily Wastewater Unit Flow Factors

Wastewater flow factors were based on water demands by land use type, as recorded in the water billing records and verified using the existing land use records. A return to sewer ratio was applied to each unadjusted water demand factor for individual land uses, and wastewater flows were balanced to wastewater treatment plant flows. Generally, non-residential land uses return the majority of the water demand to the wastewater collection system. These unit factors varied from 40 percent for special users that also utilize recycled water, to 90 percent for mixed use, commercial, and industrial land uses. The same concept can be applied to multi-family residential lots, which were estimated at a 55 percent return to sewer ratio. Single family residential lots often have the lowest return to sewer ratio. This is largely due to water lost for landscape irrigation. Single family lots were estimated at a 45 percent return to sewer ratio. Lastly, unit factors were adjusted to 100 percent occupancy, and rounded.

This analysis generally indicates that existing multi-family residential land uses have the highest flow generation factors of City land uses. The existing unit factor analysis is shown on **Table 3.2**.

As the State of California has been experiencing severe drought conditions over the past 5 years, water use has been lower than the historical average. Similarly, wastewater flows have been reduced over this same time period. While wastewater flows are down due to water conservation efforts, the majority of the conservation was observed in water use for irrigation purposes. Therefore, minimal adjustments were made to future residential unit factors. **Table 3.3** documents the recommended average dry weather flow unit factors used for estimating flows from future developments within the urban growth boundary.

3.2.3 Peaking Factors

The wastewater system is evaluated based on its ability to convey peak wastewater flows. Peaking factors represent the increase in wastewater flows experienced above the average dry weather flows (ADWF). The various peaking conditions are numerical values obtained from a review of historical data and, at times, tempered by engineering judgment.
The peaking conditions that are significant to hydraulic analysis of the wastewater collection system include peak dry weather flows and peak wet weather flows.

Table 3.2 Existing Unit Factor Analysis
Wastewater Master Plan
City of Shasta Lake

Land Use Classification[1]	Existing Service Area: Developed (net acre)	Existing Service Area: Vacant (net acre)	2014 Average Daily Water Demand Unit Factors – 2014 Water Consumption: Water Demands[2] (gpd)	Unadjusted Unit Factor (gpd/net acre)	Balance to 2014 Consumption (gpd)	Return-to-Sewer Ratio	2014 Average Dry Weather Wastewater Unit Flow Factors – 2014 Average Annual Wastewater Flows: Unadjusted Wastewater Unit Factor (gpd/net ac)	Balance to 2014 Wastewater Flows	2014 Average Dry Weather Wastewater Flows: Average Dry Weather Wastewater Unit Factor (gpd/net acre)	Average Dry Weather Wastewater Flows (gpd)	2014 Wastewater Flows at 100% Occupancy: Vacancy	Unit Factor at 100% Occupancy (gpd/net acre)	Wastewater Flow at 100% Occupancy (gpd)	Recommended Wastewater Unit Factor: Recommended Unit Factor (gpd/net acre)	Balance Using Recommended Unit Factor (gpd)
Residential															
Rural Residential A	1	0	0	0	0	0.45	0	0	0	0	6.2%	0	0	0	0
Rural Residential B	9	0	0	0	0	0.45	0	0	0	0	6.2%	0	0	0	0
Suburban Residential	208	74	121,406	584	121,406	0.45	263	54,633	158	32,829	6.2%	168	34,865	250	51,993
Urban Residential	790	193	895,665	1,133	895,665	0.55	623	492,616	375	296,015	6.2%	398	314,368	410	324,001
Urban Residential High A	0	5	215	0	0	0.55	0	0	0	0	6.2%	0	0	900	0
Urban Residential High B	80	8	47,792	596	47,792	0.55	328	26,285	197	15,795	6.2%	209	16,774	800	64,197
Subtotal	1,088	280	1,065,077		1,064,863			573,534		344,640			366,007		440,191
Non-Residential															
Mixed Use	13	50	1,468	110	0	0.90								750	10,010
Village Mixed Use	24	10	51,671	2,111	51,671	0.90								1,775	43,452
Mixed Use[3]	38	60	53,139	1,405	51,671	0.90	1,264	47,825	760	28,738	10.0%	836	31,612		53,462
Commercial	44	52	44,823	1,019	44,823	0.90	917	40,340	551	24,241	10.0%	606	26,665	590	25,963
Industrial Light	1	18	0	0	0									400	443
Industrial	72	18	41,807	582	41,807									420	30,164
Industrial[4]	73	37	41,807	573	41,807	0.90	516	37,626	310	22,610	10.0%	341	24,871		30,607
Public Facilities	64	37	24,833	390	24,833	0.60	234	14,900	140	8,954	10.0%	155	9,849	200	12,746
Special Users[5,6]	122	0	179,247	1,469	179,247	0.40	588	71,699	353	43,084	10.0%	388	47,393	490	59,780
Subtotal	340	185	343,849		290,710			212,390		127,627			140,389		182,558
Other (Non-flow generating)															
Community Park	69	-	820	12	820	0.00	0	0							
Open Space	8	-	0	0	0	0.00	0	0							
Federal Government	9	-	0	0	0	0.00	0	0							
Freeway	5	-	0	0	0	0.00	0	0							
Railway	0	-	0	0	0	0.00	0	0							
Easement	1	-	0	0	0	0.00	0	0							
ROW	31	-	0	0	0	0.00	0	0							
Subtotal	123	0													

Total Wastewater Flows

Total Annual Flow Using Unadjusted Unit Factors (gpd)	785,924
Average Annual WWTP Flow[7] (gpd)	780,274
Total Dry Weather Flow Using Unadjusted Unit Factors	472,266
Average Dry Weather WWTP Flow[7] (gpd)	468,871
Total ADWF Using Recommended Unit Factors (gpd)	622,749
10 Year Average WWTP ADWF (gpd)	632,000

Notes:
1. Source: General Plan Land Use shapefile received from Dynamic Planning staff July 1, 2016.
2. Source: "2014 Water Billing Records" received from City staff August 25, 2015
3. Includes "Mixed Use" and "Village Mixed Use"
4. Includes "Industrial" and "Industrial Light" Land Use Types
5. Top 2 industrial water customers (Knauf Insulation and Sierra Pacific Sawmill) as extracted from 2014 Water Billing Records
6. Developed acres estimated based on aerial imagery.
7. Source: 2014 WWTP flow data received from City staff August 4, 2015

7/15/2016

Table 3.3 Recommended ADWF Wastewater Unit Factors

Wastewater Master Plan

City of Shasta Lake

Land Use Clarifications	Recommended Factor (gpd/net acre)
Residential	
Suburban Residential	250
Urban Residential	410
Urban Residential High A	900
Urban Residential High B	800
Non-Residential	
Mixed Use	750
Village Mixed Use	1,775
Commercial	590
Industrial Light	400
Industrial	420
Public Facilities	200
Special Users[1]	490

Notes:

7/15/2016

1. Top 2 industrial water customers (Knauf Insulation and Sierra Pacific Sawmill) as extracted from 2014 Water Billing Records

The City's 2005 WWMP included a peaking factor curve for dry weather flows and another curve for wet weather flows. This study developed a 24-hour diurnal pattern and peaking factors for dry weather flows for the wastewater collection system, as shown on **Figure 3.1**. It should be noted that the diurnal pattern shown on **Figure 3.1** accounts for travel time from when flow enters the system to when it reaches the WWTP. This travel time, also known as flow attenuation, results in peaks at the WWTP that may be several hours after the flow actually enters the system. Due to varying travel times in the system, peak flows are often higher in the upper reaches of the wastewater collection system than at the WWTP.

3.3 WET WEATHER FLOW CRITERIA

The wet weather flow criteria accounts for the infiltration and inflows (I&I) that seep into the City's wastewater collection system during storm events.

3.3.1 Infiltration and Inflow

Groundwater infiltration and inflow is associated with extraneous water entering the sewer through defects in pipelines and manholes. Infiltration occurs when groundwater rises or the soil is saturated due to seasonal factors such as a storm event which causes an increase in flows in the wastewater collection system. The groundwater will enter the wastewater collection system through cracks in the pipes or deteriorating manholes. Inflow occurs when surface water enters the wastewater collection system from storm drain cross connections, manhole covers, or roof/footing drains. **Figure 3.2** was developed by King County, Washington and was included in this chapter to illustrate the typical causes of infiltration and inflow.

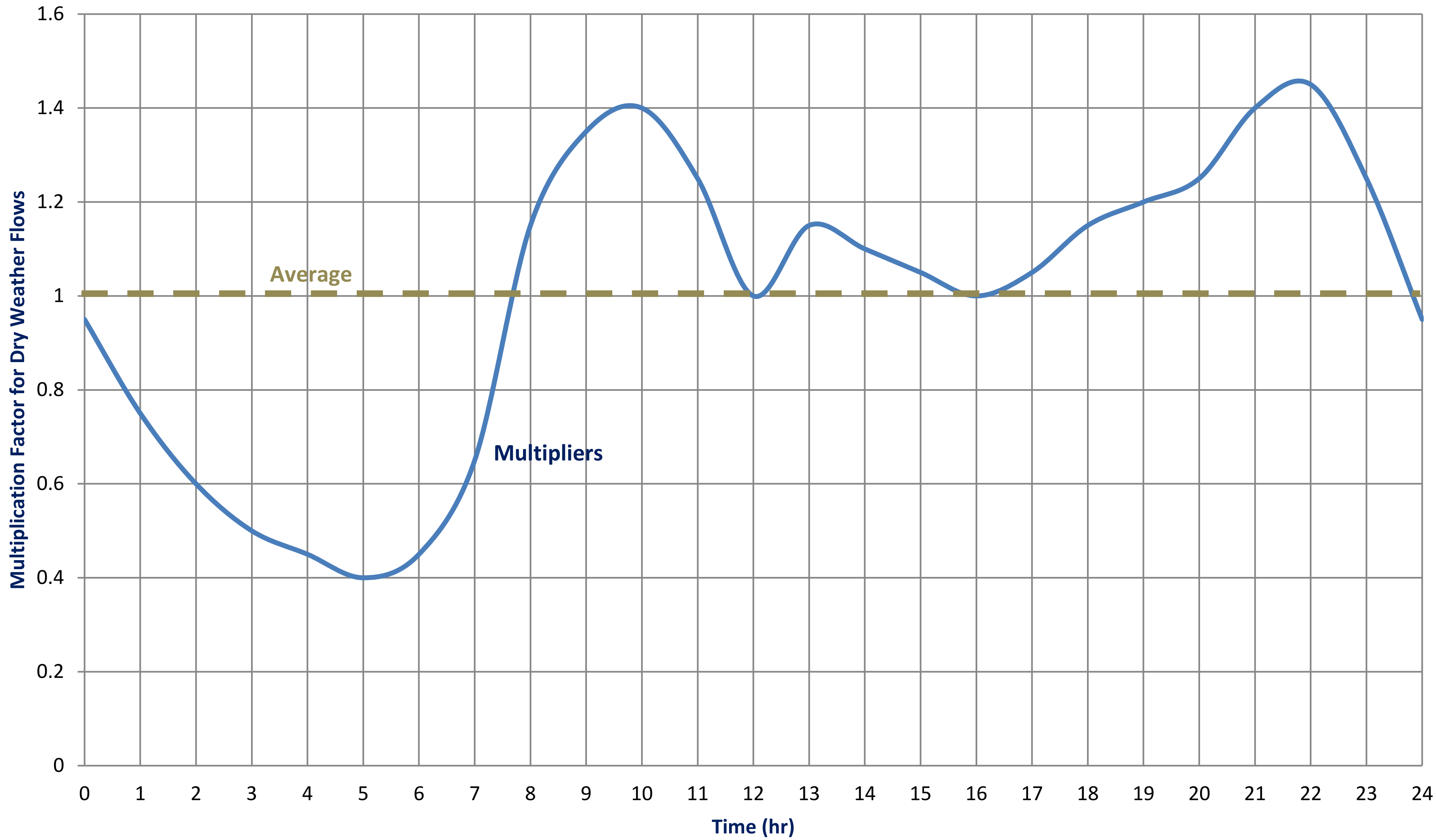
There are several accepted methodologies for estimating infiltration and inflows (I&I). These include:

- **Methodology 1.** Based on Acreages. In this methodology, factors that may range between 400 and 1,500 gallons per day (gpd) or more are applied to acreages for estimating the I&I component.

- **Methodology 2.** Based on Linear Feet of Pipe. In this methodology, factors that may range between 12 and 30 or more gallons per day per inch diameter per 100 linear feet (gpd/inch diameter/100LF) are applied to linear feet of gravity sewers.

- **Methodology 3**. Based on a percentage of Average Dry Weather Flows. In this methodology, infiltration and inflows are calculated based on a percentage of the average dry weather flow.

- **Methodology 4**. Based on flow monitoring data. In this methodology, infiltration and inflows are determined by analyzing flow monitoring data of current and past flow monitoring efforts.



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Diurnal Pattern

Note:
A diurnal pattern is a representation of time and intensity of sewer flows as they enter the collection system. The multiplication factors indicate the intensities of the peaks compared to the average.

September 23, 2016

Figure 3.1
Baseflow Diurnal
Wastewater Master Plan
City of Shasta Lake

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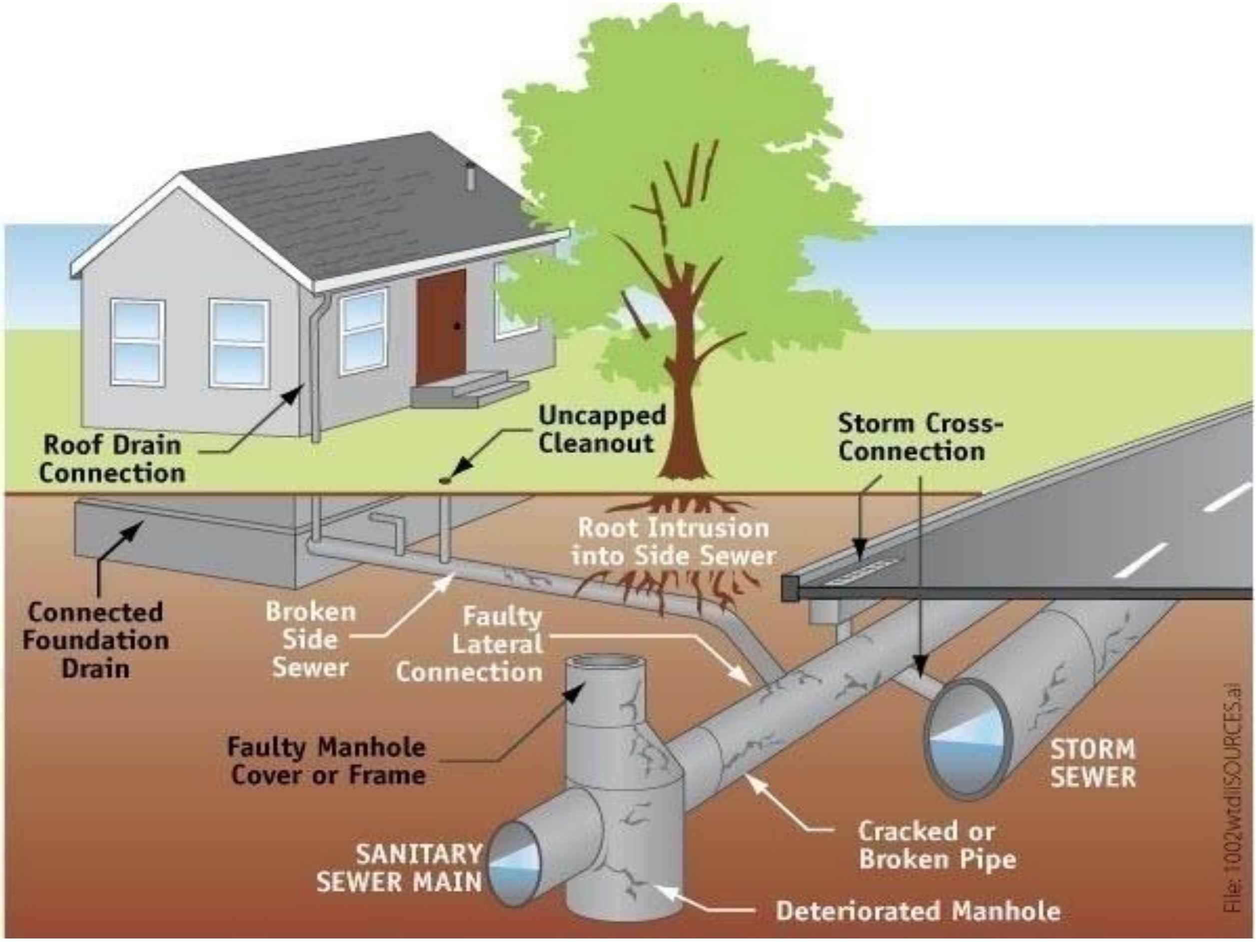


Source: King County, WA
http://www.kingcounty.gov/environment/wastewater/II/What.aspx?print=1

August 25, 2016

LEGEND

Inflow Sources (Black Text)

Infiltration Sources (White Text)

Figure 3.2

Infiltration and Inflow Sources

Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

3.3.2 10-Year 24-Hour Design Storm

A synthetic design storm is typically used to evaluate the wastewater collection system's response during wet weather flow conditions. The design storm information was extracted from Depth-Duration-Frequency rainfall data available from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (**Table 3.4**).

- **10-Year Frequency.** Industry standards include design storms that range between 5-year and 20-year events. Based on current regulatory trends, a 10-year storm event was chosen for the City to evaluate the capacity adequacy of the wastewater collection system.

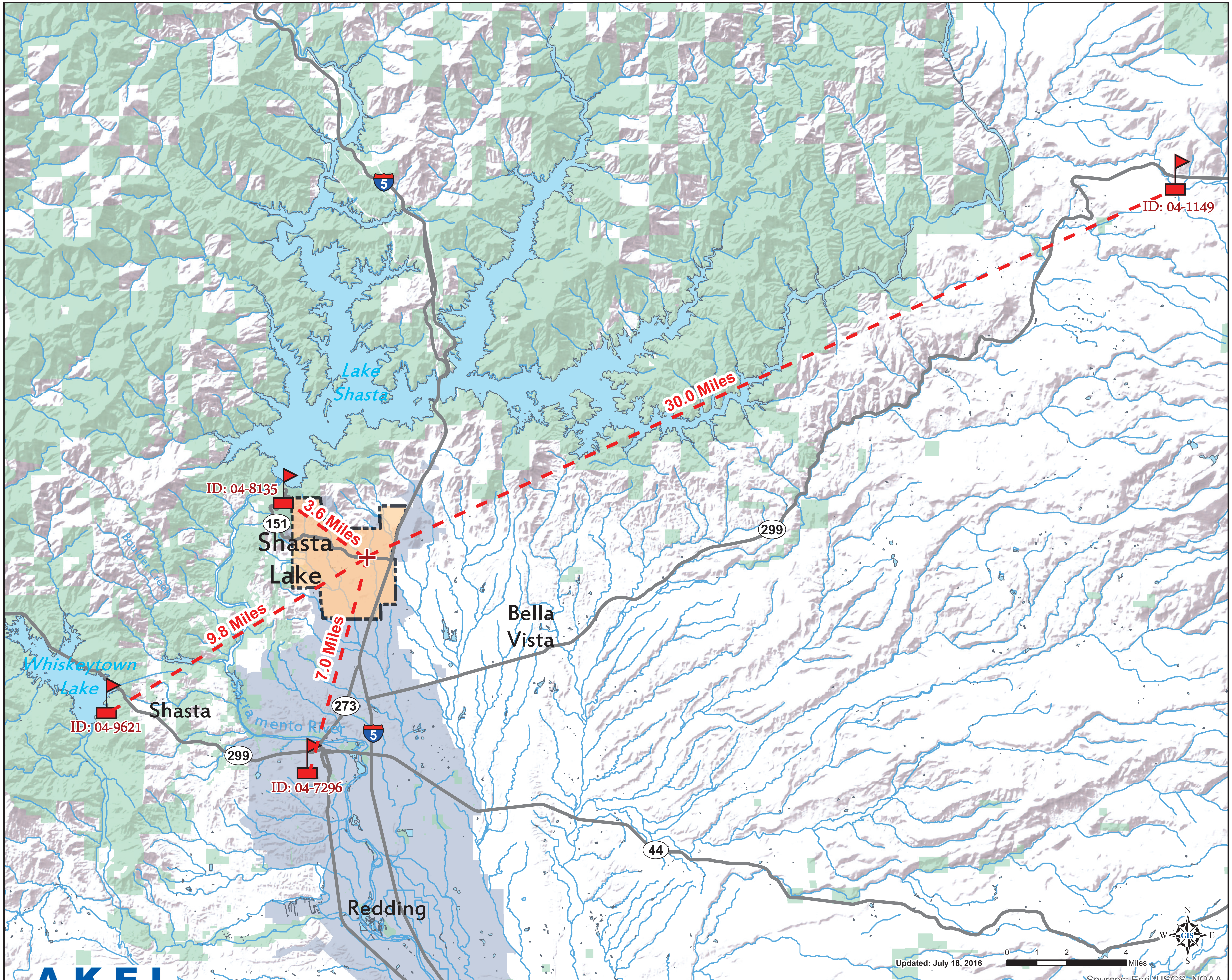
- **24-Hour Duration.** Peak flows from a storm event are usually cause by brief intense rains, that can happen as part of an individual event or as a portion of a larger storm. The 24-hour storm duration is longer than needed to determine peak flow but aids in identifying infiltration and inflows a sewer system may experience during a storm event.

- **Balanced Rainfall Centered Distribution.** The National Resources Conservation Service, previously known as the Soil Conservation Service, has developed rainfall distributions for wide geographic regions based on traditional DDF rainfall data. In this methodology, the highest rainfall intensity is placed at the center of the storm. Incrementally lower intensities are placed on alternating sides of the peak.

Thus, the NOAA Atlas 14 DDF, 10-year 24-hour (10yr-24hr) design storm, with a balanced rainfall distribution, was used to evaluate the capacity adequacy of the City's wastewater collection system during wet weather flow conditions.

The selected 10-year 24-hour design storm was further compared to historical storm events, between December 2005 and December 2014, as shown on **Table 3.5**. The table lists the total rainfall volume, peak hour intensity, and total monthly rainfall (if available) for each storm event. Historical rainfall data for the December 2005 and December 2014 storm events was not immediately available for the City; therefore, historical data was compiled from rain stations in proximity to the City (**Figure 3.3**). Historical data for these stations was extracted from the Department of Water Resources (DWR) Climate Data Exchange Center (CDEC) and the average rainfall values, weighted based on distance from the City, were used to characterize the City's historical rainfall totals.

Figure 3.4 is intended to show the diurnal comparison between the design storm and the two storm events experienced during December of 2005 and 2014. The comparison indicates that, based on the balanced centered hyetograph, the design storm's peak hour value is at 1.41 inches per hour (in/hr), while the December 2005 and 2014 storms peak values are 0.31 and 0.69 in/hr respectively. This comparison illustrates the more conservative nature of the design storm and the smaller peak values of the storm events experienced in December 2005 and 2014.



Legend

- NOAA Rain Stations
- City of Shasta Lake
- Urbanized Area
- Protected Open Space
- Major Highways
- Rivers/Streams
- Waterbodies

Figure 3.3
NOAA Rain Stations

Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

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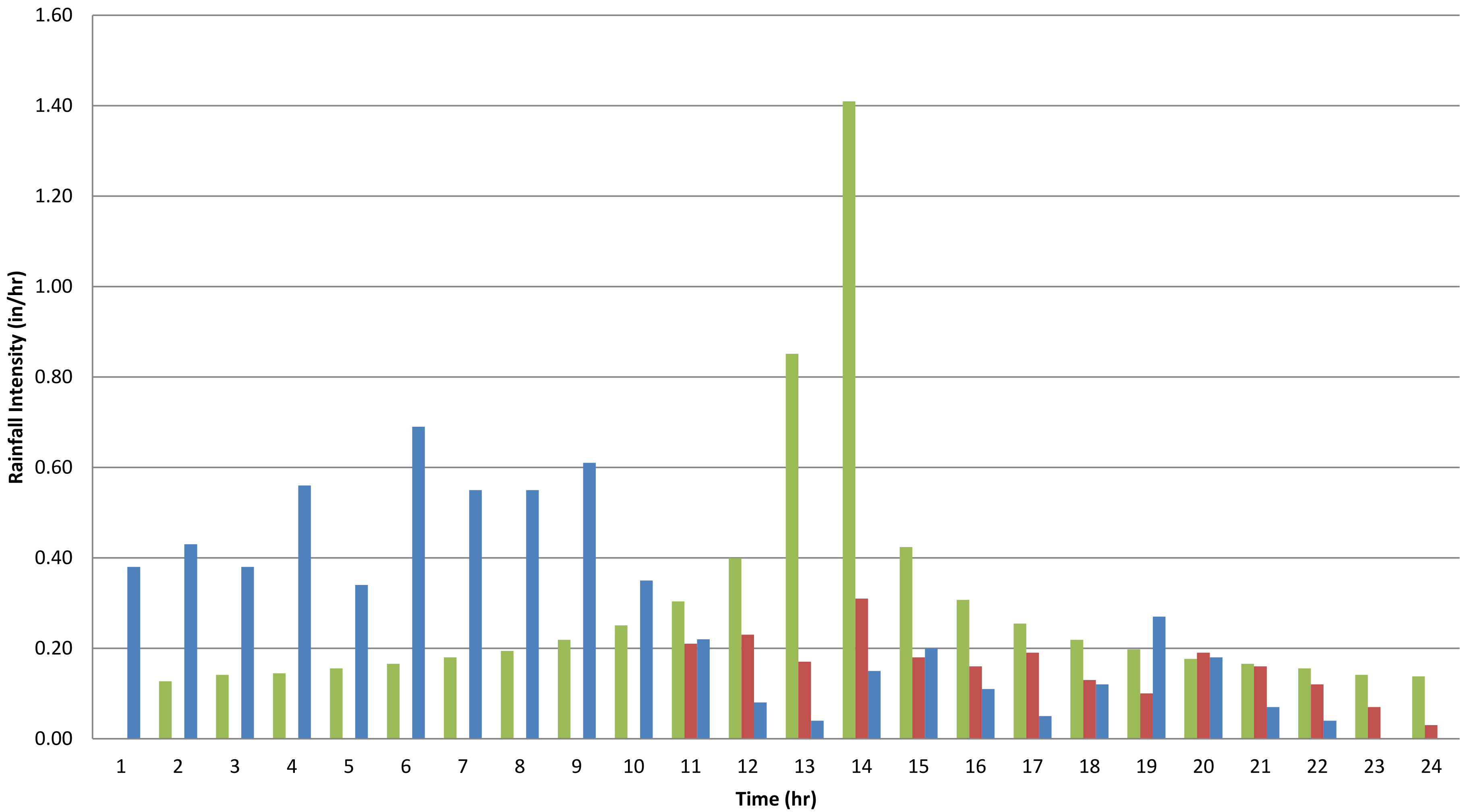

LEGEND

- Design Storm: 10 Year - 24 Hour (6.72 in)
- Historical Storm Event 1: December 31, 2005 (2.25 in)
- Historical Storm Event 2: December 31st, 2014 (6.37 in)

September 23, 2016

AKEL ENGINEERING GROUP, INC.

Figure 3.4

10-Year 24-Hour Storm
(Design vs. Historical Storms)

Wastewater Master Plan
City of Shasta Lake

Table 3.4 Precipitation Depth-Duration-Frequency Data

Wastewater Master Plan
City of Shasta Lake

Duration	2-Year		5-Year		10-Year		100-Year	
	(in)	(in/hr)	(in)	(in/hr)	(in)	(in/hr)	(in)	(in/hr)
5 min	0.27	3.24	0.34	4.08	0.39	4.68	0.55	6.60
10 min	0.39	2.34	0.48	2.88	0.56	3.36	0.79	4.74
15 min	0.47	1.88	0.58	2.32	0.67	2.68	0.96	3.84
30 min	0.65	1.30	0.81	1.62	0.93	1.86	1.32	2.64
1 hr	0.92	0.92	1.14	1.14	1.32	1.32	1.88	1.88
2 hr	1.29	0.65	1.59	0.80	1.82	0.91	2.60	1.30
3 hr	1.58	0.53	1.93	0.64	2.21	0.74	3.15	1.05
6 hr	2.28	0.38	2.76	0.46	3.15	0.53	4.45	0.74
12 hr	3.32	0.28	4.03	0.34	4.59	0.38	6.40	0.53
24 hr	4.92	0.21	6.00	0.25	6.85	0.29	9.51	0.40
2 day	6.53	0.14	8.02	0.17	9.20	0.19	13.08	0.27
10 day	12.34	0.05	15.27	0.06	17.53	0.07	24.50	0.10
30 day	19.96	0.03	24.57	0.03	28.03	0.04	38.22	0.05

Notes: 7/20/2016

1. Precipitation Depth-Duration-Frequency data estimated based on NOAA Atlas 14 precipitation frequency estimates.

Table 3.5 Storm Events Analysis

Wastewater Master Plan

City of Shasta Lake

Storm Event	Estimated Return Interval	Single Rainfall Event Volume and Intensity		Total Monthly Rainfall
		Volume	Peak Intensity	
		(in)	(in//hr)	(in)
December 31, 2005	1-Year 24-Hour	2.25	0.31	22.8
December 31, 2014	10-Year 24-Hour	6.37	0.69	22.1
Design Storm	10-Year 24-Hour	6.72	1.41	-

7/20/2016

per hour (in/hr), while the December 2005 and 2014 storms peak values are 0.31 and 0.69 in/hr respectively. This comparison illustrates the more conservative nature of the design storm and the smaller peak values of the storm events experienced in December 2005 and 2014.

CHAPTER 4 - EXISTING WASTEWATER COLLECTION FACILITIES

This chapter provides a description of the City's existing wastewater system facilities including gravity trunks, force mains, lift stations, and wastewater collection basins. The chapter also includes a brief description of the Shasta Lake Wastewater Treatment Plant.

4.1 WASTEWATER COLLECTION SYSTEM OVERVIEW

The City provides sewer collection services to approximately 3,800 residential, commercial, industrial, and institutional accounts. The City's collection system consists of approximately 54 miles of up to 21-inch gravity sewer pipes that convey flows towards the Shasta Lake WWTP, on Pine Grove Avenue as shown on **Figure 4.1**.

In addition to the existing sewer service accounts there are more than 500 points of septic service located within the City limits, as shown on **Figure 4.2**.

A system-wide pipe inventory, listing the total length by pipe diameter, is shown on **Table 4.1**. This table is based on information extracted from the City's GIS. The 6-inch and 8-inch diameter pipes account for 93 percent of the total gravity main pipe lengths.

4.2 WASTEWATER COLLECTION BASINS AND TRUNKS

Due to topography, the wastewater collection system is divided into six separate dendritic wastewater collection basins, each defining the boundaries of a wastewater collection trunk system. The six major wastewater collection basins, shown on **Figure 4.3**, were largely based on the tributary areas to the lift stations located within the City. A schematic diagram intended to simplify the connectivity between the basins and trunks is shown on **Figure 4.4**. The basins were further divided into collection system subbasins, and the basins are documented in the following sections.

4.2.1 Basin 1

Basin 1 is comprised of one collection subbasin, subbasin 1A, and encompasses 126 acres in the northwest portion of the City. This basin includes the areas generally west of Rouge Road and north of Shasta Dam Boulevard. This basin collects flows near the intersection of Park Street and Poplar Street with a 6-inch trunk. The flows are collected and conveyed through a 6-inch force main, before continuing by gravity main to Basin 4.

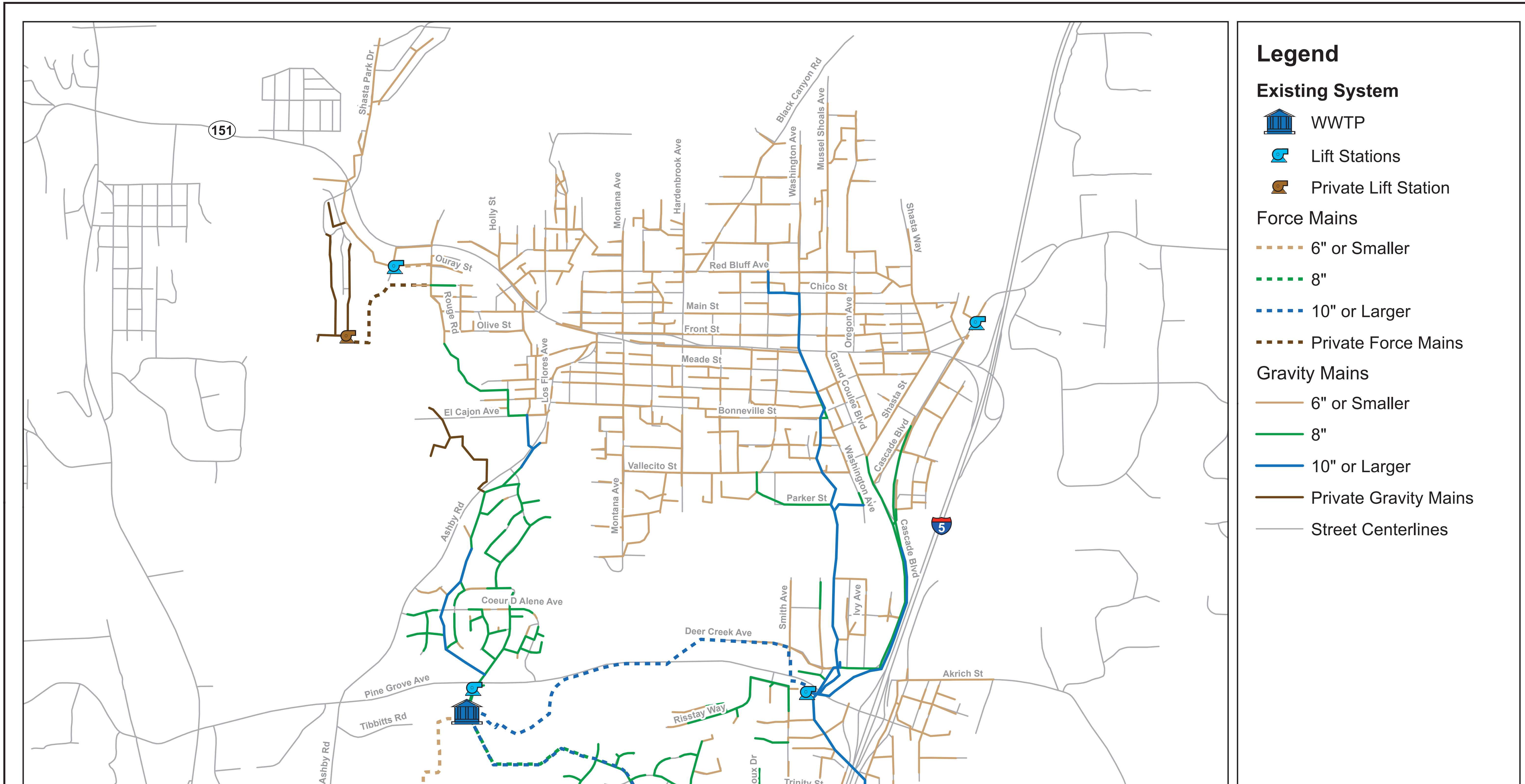

Figure 4.1
Existing Wastewater Collection System
Wastewater Master Plan
City of Shasta Lake

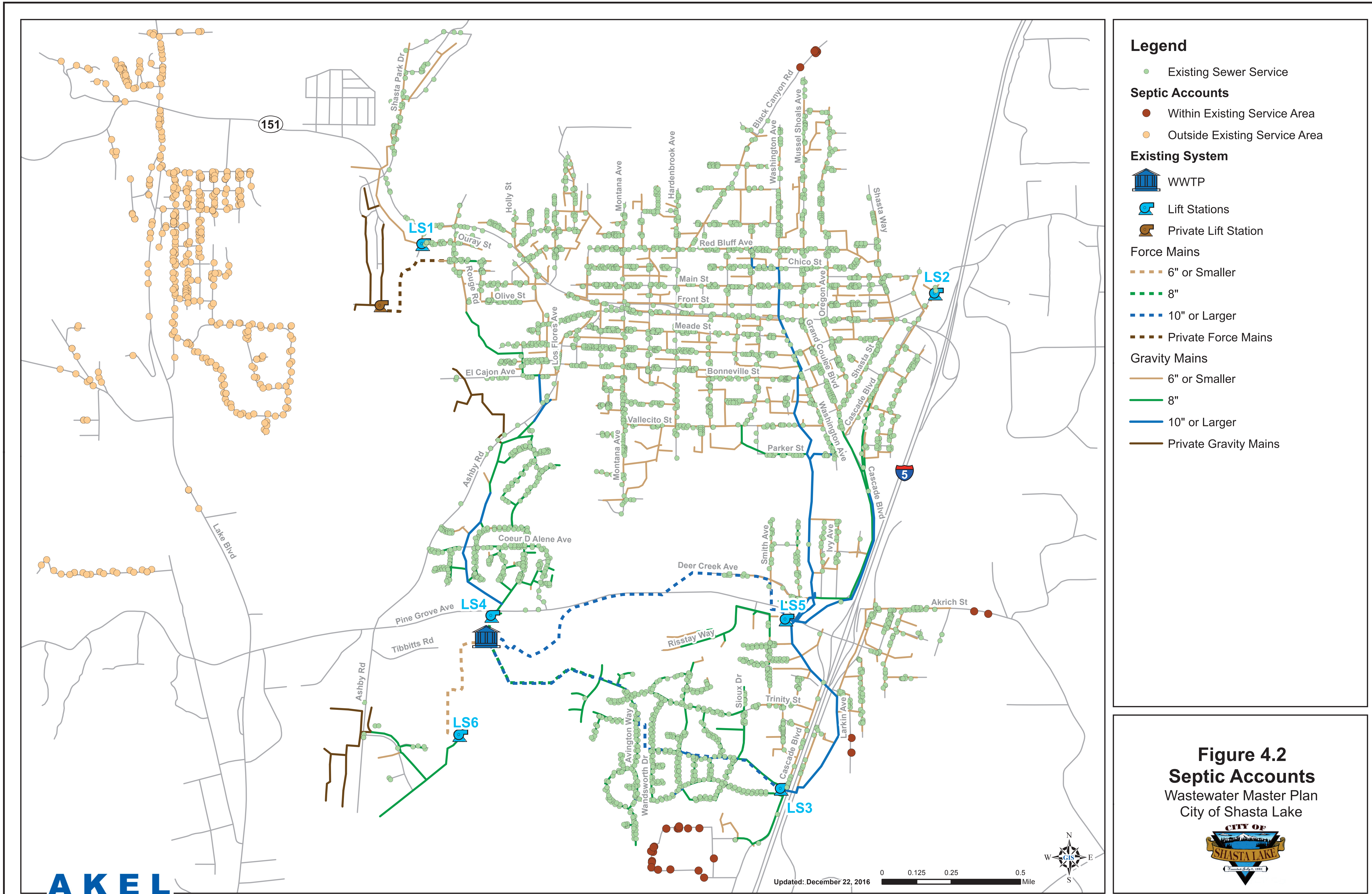

Figure 4.2
Septic Accounts
Wastewater Master Plan
City of Shasta Lake

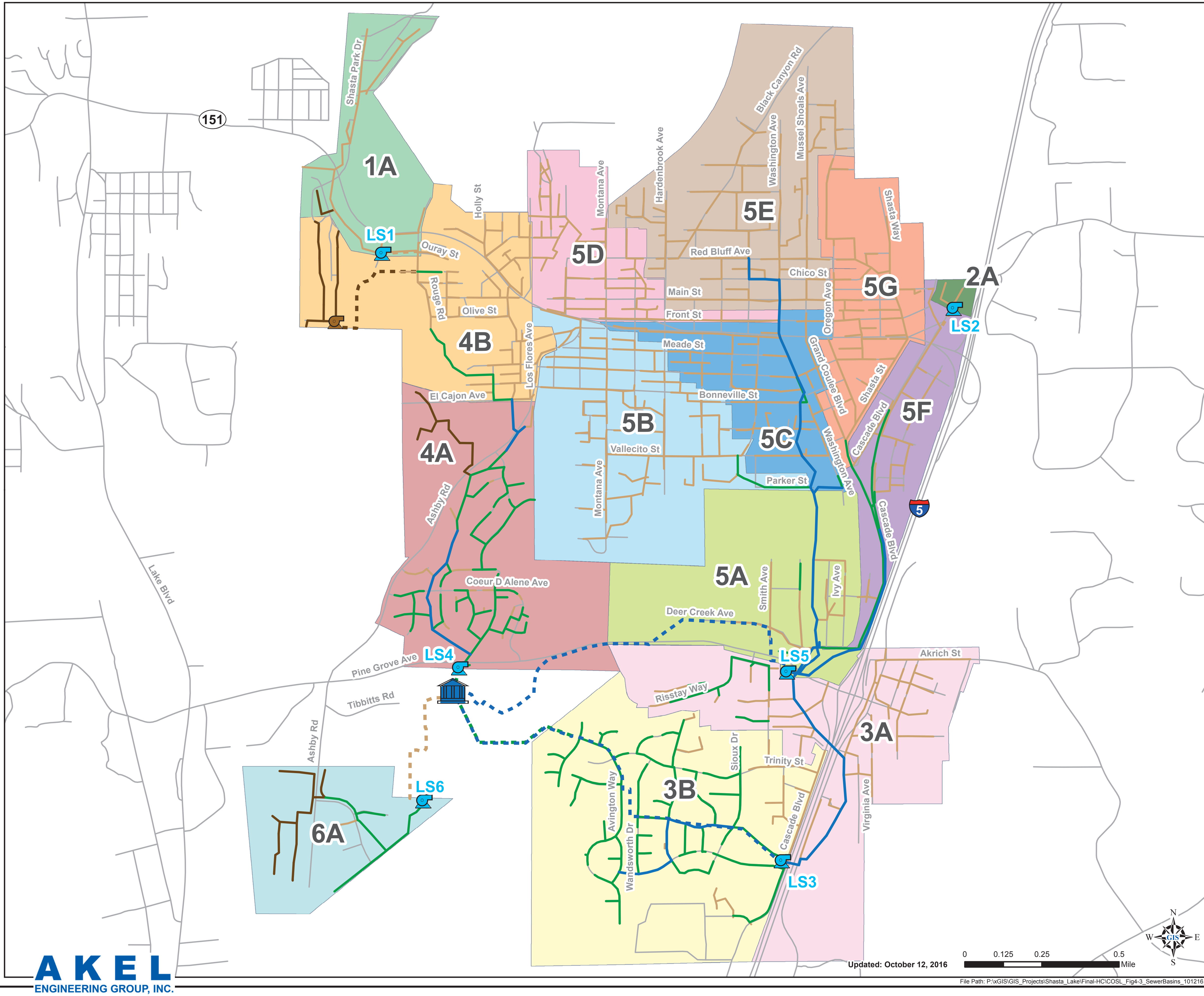

Figure 4.3
Existing Wastewater Collection System Basins
Wastewater Master Plan
City of Shasta Lake

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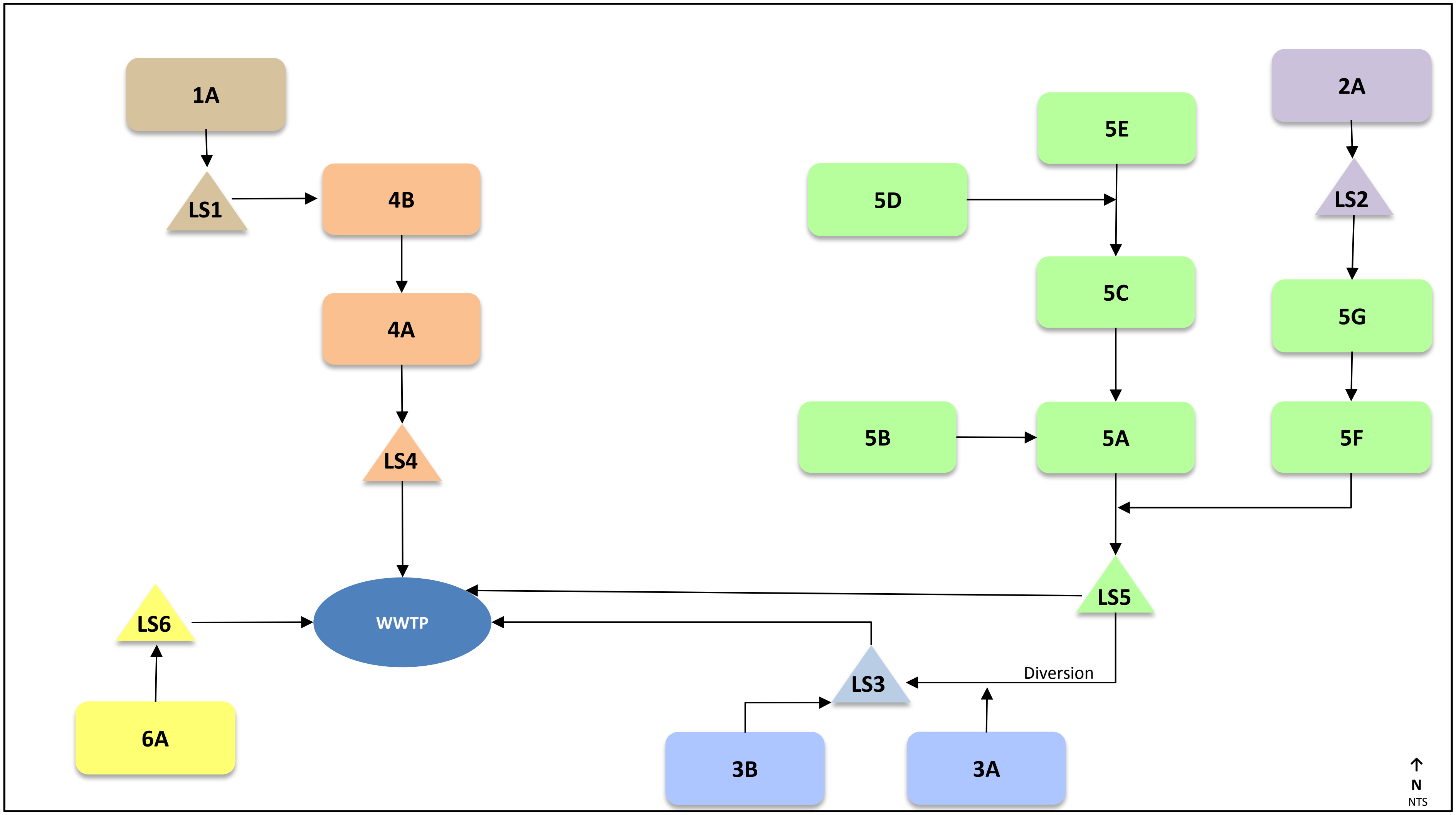


LEGEND

Wastewater Tributary Area

Wastewater Lift Station

Wastewater Trunks

May 5, 2016

Figure 4.4
Wastewater Tributary Areas
Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

Table 4.1 Existing GIS Pipe Inventory
Wastewater Master Plan
City of Shasta Lake

Pipe Size (in)	Pipe Length (ft)	(miles)
Gravity Mains		
6	195,498	37.0
8	70,775	13.4
10	7,902	1.5
12	5,973	1.1
14	147	0.0
15	2,876	0.5
18	2,830	0.5
21	673	0.1
Subtotal	286,672	54.3
Force Mains		
4	421	0.1
6	3,322	0.6
8	3,082	0.6
10	6,880	1.3
14	8,055	1.5
Subtotal	21,760	4.1
Total		
	308,432	**58.4**

5/6/2016

4.2.2 Basin 2

Basin 2 is comprised of one collection subbasin, collection subbasin 2A, and encompasses 8 acres in the northwest portion of the City. This basin currently includes a small area along Cascade Boulevard generally north of Kennett Street. This basin will also include a commercial center planned to develop in the future. This basin collects flows approximately 700 feet north of the intersection of Shasta Dam Boulevard and Cascade Boulevard with a 6-inch trunk. The flows are collected and conveyed through a 4-inch force main, before continuing by gravity main to Basin 5.

4.2.3 Basin 3

Basin 3 is comprised of two collection subbasins, collection subbasins 3A and 3B, which respectively encompass 320 acres and 430 acres in the southeast portion of the City. This basin includes the areas generally south of Pine Grove Avenue and east of Westminster Court.

The 3A and 3B subbasins, which border one another, collect flows near the corner of Autumn Harvest Drive and Cascade Boulevard. From the 3A subbasin the flows are collected via a single 12-inch trunk, whereas the flows collected from the 3B subbasin are from one 6-inch and one 8-inch trunk. The flows are collected at Lift Station 3, where they are conveyed through a series of 8-inch, 10-inch, and 14-inch force mains to the City WWTP.

4.2.4 Basin 4

Basin 4 is comprised of two collection subbasins, collection subbasins 4A and 4B, which respectively encompass 303 and 227 acres in the western portion of the City. Collection subbasin 4B, which includes the areas generally west of North Boulevard and north of El Cajon Avenue, collects flows at El Cajon Avenue between Mesquite Street and Los Flores Street with a 10-inch trunk, where they conveyed by gravity main to collection subbasin 4A; collection subbasin 4B also conveys flows from collection subbasin 1A. Collection subbasin 4A collects flows approximately 1,000 feet west of the intersection of Pine Grove Avenue and Coeur D'Alene Avenue with an 8-inch trunk. The flows are collected and conveyed through a 10-inch force main to the City WWTP.

4.2.1 Basin 5

Basin 5 is comprised of seven collection subbasins 5A, 5B 5C, 5D, 5E, 5F, and 5G. The 5D and 5E subbasins, respectively encompassing 123 and 306 acres, collect flows west and north of the intersection of Front Street and Washington Avenue, where flows combine in a 15-inch trunk and enter collection subbasin 5C.

The 5B and 5C subbasins, respectively encompassing 283 and 138 acres, collect flows west and north of the intersection Parker Street and Washington Avenue, where flows combine in an 18-inch trunk and enter collection subbasin 5A. Collection subbasin 5A encompasses 233 acres and collects flows north of Pine Grove Avenue, as well as flows from collection subbasin 2A, before conveying them to Lift Station 5. The 5G subbasin encompasses 145 acres north of the intersection of Shasta Way and Morning Star Way, where flows are collected in 6-inch and 8-inch trunks before entering Subbasin 5F. The 5F subbasin encompasses152 acres north of Deer

Creek Avenue between Shasta Way and Interstate-5, and collects flows in 6-inch and 8-inch trunks before being conveyed to Lift Station 5.

The flows are collected at Lift Station 5, where they are conveyed through a 14-inch force main to the City WWTP. It should be noted that just upstream of Lift Station 5, flows may bypass

4.2.2 Basin 6

Basin 6 is comprised of one collection subbasin, collection subbasin 6A, and encompasses 134 acres in the southwest portion of the City. This basin includes the areas generally south of Pine Grove Avenue and west of the Shasta Lake WWTP. This basin collects flows near Iron Court with an 8-inch trunk. The flows are collected at Lift Station 6 and conveyed through a 6-inch force main to the City WWTP.

4.3 LIFT STATIONS

When routing flows by gravity is not possible due to adverse grades, lift stations are used to pump flows. The City currently maintains six lift stations in the wastewater collection system, as summarized on **Table 4.2** and shown on **Figure 4.5**.

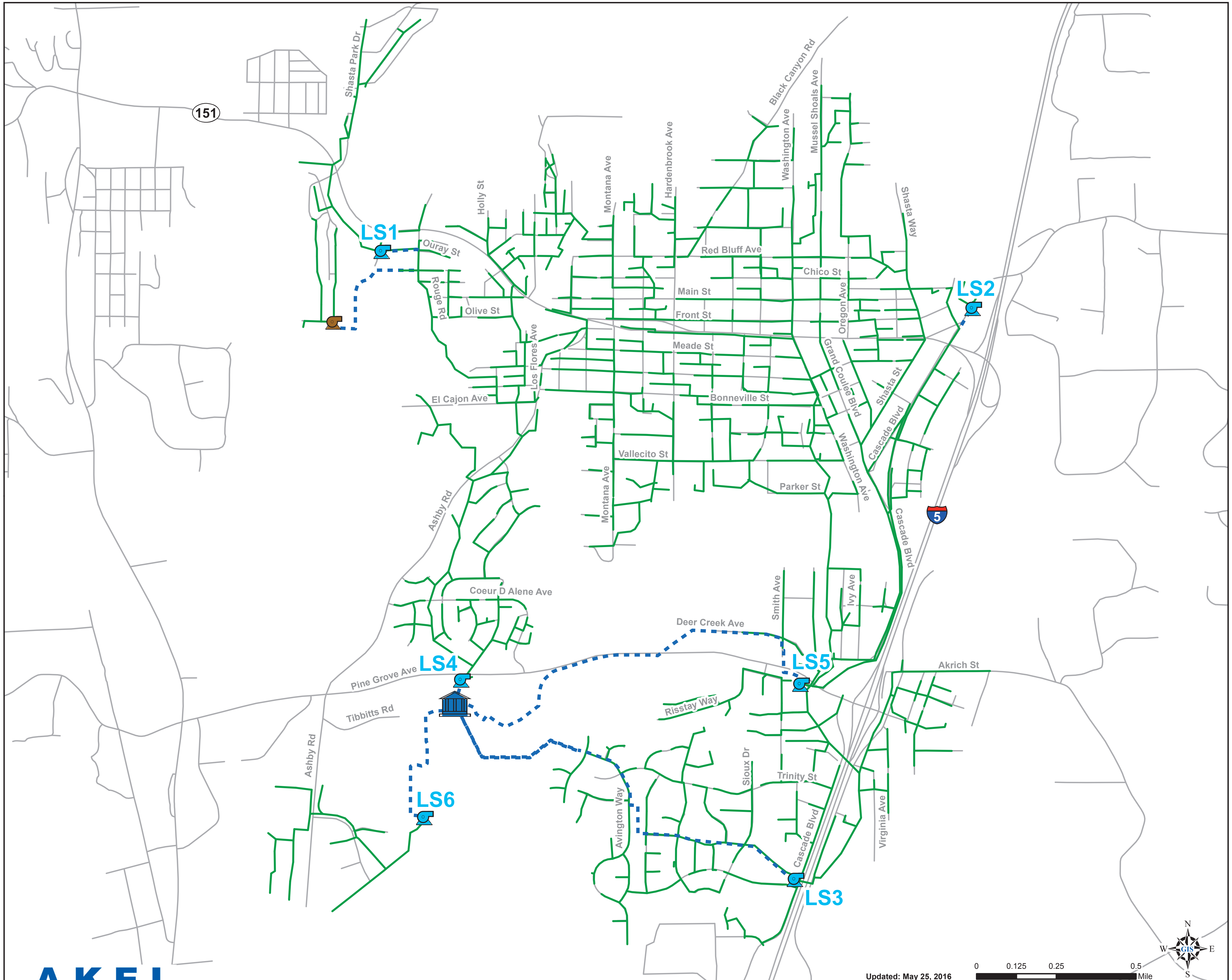
Table 4.2 lists each lift station with relevant information obtained from the City's records including: location, type, wet well information, number of pumps, pump capacity, and controls, if data was available. The lift stations are operated to turn "on" or "off" based on the levels in their wet wells.

Each of the six lift stations were included in the hydraulic model and a brief description of the lift stations is as follows:

- **Lift Station 1.** This lift station services the area west of Rouge Road and north of Park Street. This lift station is located at the intersection of Poplar Street and Park Street. The lift station includes one duty pump and one standby pump. The pump station firm capacity is approximately 0.5 MGD and has a total capacity of 1.0 MGD. The pumps discharge into a 6-inch force main along Park Street.

- **Lift Station 2.** This lift station services the area north of the intersection of Kennett Street and Cascade Boulevard. This lift station is located on Cascade Boulevard approximately 270 feet north of Kennett Street. The lift station includes one duty pump. The pump station firm capacity is 0.06 MGD. The pump discharges into a 4-inch force main along Cascade Boulevard.

- **Lift Station 3.** This lift station services the area south of Lift Station 5, and east of Interstate 5. This lift station is located at the intersection of Cascade Boulevard and Autumn Harvest Way. The lift station includes two duty pumps and one standby pump with a firm capacity of 2.4 MGD and its total capacity at 3.8 MGD. The pumps discharge into a 10-inch force main that jogs within various sections of right-of-way along Impression Way and Avington Way. The force main changes size to a 14-inch near Doyle Court and



Legend

Existing System

- WWTP
- Lift Stations
- Private Lift Station
- Force Mains
- Gravity Mains
- Street Centerlines

Figure 4.5
Existing
Lift Stations
Wastewater Master Plan
City of Shasta Lake

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Table 4.2 Lift Station Inventory
Wastewater Master Plan
City of Shasta Lake

Lift Station Information			Wet Well Dimensions						Pumps			Estimated Capacity		Pump Controls							
No.	Location	Type	Diameter (ft)	Length (ft)	Width (ft)	Depth (ft)	Rim Elevation (ft)	Invert (ft)	Quantity	Capacity (mgd)	TDH (ft)	Firm[1] (mgd)	Total (mgd)	High (ft)	Low (ft)	Lead On (ft)	Lead Off (ft)	Lag 1 On (ft)	Lag 1 Off (ft)	Lag 2 On (ft)	Lag 2 Off (ft)
1	Intersection of Poplar St and Park St	Dry Pit	---	11.3	4.8	12.0	843.0	831.0	2	2 @ 0.5	2 @ 60	0.50	1.00	836.0	831.7	834.5	832.5	835.0	832.5		
2	Cascade Blvd, 270 ft northeast of Kenneth St	Ejector Pot							2[2]			0.06[2]									
3	Intersection of Cascade Blvd and Autumn Harvest Way	Dry Pit	---	20.0	4.5	9.5	647.5	638.0	3	2 @ 1.2 1 @ 1.4	2 @ 170 1 @ 180	2.40	3.80	646.0	639.0	640.0	639.5	643.0	640.0	644.5	642.0
4	500 feet north of Wastewater Treatment Plant	Dry Pit	---	12.2	5.0	16.8	704.0	687.2	2			1.44[2]				690.9	689.0	693.3	689.0		
5	Intersection of Pine Grove Ave and Cascade Blvd	Submersible - Adjustable Speed Drive	8.5	---	---	23.8	682.0	658.2	2	1 @ 3.2 1 @ 2.9	1 @ 170 1 @ 177	2.90	6.10	667.7	661.3	663.3	662.3	667.2	661.8		
6	1,200 feet east of the intersection of Iron Ct and Shasta Gateway Dr	Submersible	6.0	---	---	13.5	711.0	697.5	2	2 @ 0.31	2 @ 68	0.31	0.62			700.5	699.0	702.0	700.5		

Notes:

9/23/2016

1. Unless noted otherwise, estimated firm capacity equal to lift station capacity with largest pump out of service.
2. Lift Station information extracted from City of Shasta Lake 2015 Sewer System Management Plan.

Chaucer Way, before manifolding into a split force main approximately 150 feet west of Chaucer Way. The split force main consists of an 8-inch and 10-inch, which continue to the City WWTP, where they combine into an 8-inch force main prior to discharge.

- **Lift Station 4.** This lift station services the western portion of the city that is north of Pine Grove Avenue. This includes all area serviced by Lift Station 1, as well as the area immediately west of North Boulevard, Ashby Road, Woodley Avenue, Craftsmen Avenue, and Coeur D'Alene Avenue. This lift station is located 500 feet north of the City WWTP. The lift station includes one duty pump and one standby pump and has a firm capacity of 1.44 MGD. The pumps discharge into an 8-inch force mains that head southward until reaching the City WWTP.

- **Lift Station 5.** This lift station services the middle and eastern area of the city that is north of Pine Grove Avenue. This includes all area serviced by Lift Station 2, as well as the area immediately east of North Boulevard and Ashby Road. This lift station is located at the intersection of Pine Grove Avenue and Cascade Boulevard. The lift station includes one duty pump and one standby pump that are rated at 2.9 MGD and 3.2 MGD respectively. The pumps discharge into a 14-inch force main that heads eastward along Pine Grove Avenue until reaching the City WWTP.

- **Lift Station 6.** This lift station serves the corner of the city that is south and west of the Shasta Lake Wastewater Treatment Plant. This lift station is located 1,200 feet east of the intersection of Iron Court and Shasta Gateway Drive. This lift station includes one duty and one standby pump, both rated at 0.31 MGD. The lift station discharges into a 6-inch force that heads north until reaching the City WWTP.

4.3.1 Lift Station 3 and 5 Force Main Replacement

City staff have indicated that the force mains discharging from Lift Station 3 and Lift Station 5 are near capacity. Although a force main routing analysis was not completed as part of this master plan, City staff have indicated the need for potential realignment alternatives. The force mains are further discussed as follows:

- **Lift Station 3 Force Main.** The force main from Lift Station 3 is undersized, and has been identified by City staff as deficient. Additionally, the force main is located in easements with limited access. Due to the capacity and access limitations, the City is planning to replace the force main. Prior to replacement, the City may conduct an alignment alternatives analysis to determine the most cost effective routing option for the force main. This may include routing the new force main to Pine Grove Avenue, and paralleling the force main from Lift Station 5.

- **Lift Station 5 Force Main.** The force main from Lift Station 5 is undersized for future flows, and has alignment restrictions. The force main begins on Pine Grove Avenue, but jogs north to Deer Creek Avenue, and then back to Pine Grove Avenue. City staff have indicated that the portion of force main along Deer Creek Avenue should be realigned to Pine Grove Avenue.

4.4 SHASTA LAKE WASTEWATER TREATMENT PLANT

The Shasta Lake WWTP is a 1.3 MGD advanced secondary treatment plant that is designed to meet Title 22 requirements for reuse purposes. The facility is located on Tibbits Road with a street address of 3700 Tibbits Road. The plant was built in 1996 to replace an extended aeration treatment facility constructed in. Shasta Lake WWTP has a design capacity of 1.3 MGD and it can accommodate a design peak dry weather flow of up to 5.3 MGD. The plant is currently operating at an average flow of 0.8 MGD and is being upgraded to allow year-round discharge.

CHAPTER 5 – WASTEWATER FLOWS

This chapter summarizes historical wastewater flows experienced at the Shasta Lake WWTP and defines flow terminologies relevant to this evaluation. This chapter discusses the wastewater flow distribution within the six basins, and identifies the design flows used in the hydraulic modeling effort and capacity evaluation. The design flows include the existing condition (existing customers) and the projected ultimate buildout scenario.

5.1 FLOWS AT THE SHASTA LAKE WWTP

The wastewater flows collected and treated at the Shasta Lake WWTP vary monthly, daily, and hourly. While the dry weather flows are influenced by customer uses, the wet weather flows are influenced by the severity and length of storm events. Figure 5.1 shows the monthly flows versus rainfall at the WWTP for 2014, where December was the maximum month during 2014.

Flow data influent to the Shasta Lake WWTP was obtained from City operation staff. The flow data covered a period from 2004 to 2014. From this data monthly, daily, peak daily flows, and peak hourly flows (if available), were determined as summarized on Table 5.1.

The following definitions are intended to document relevant terminologies shown on Table 5.1:

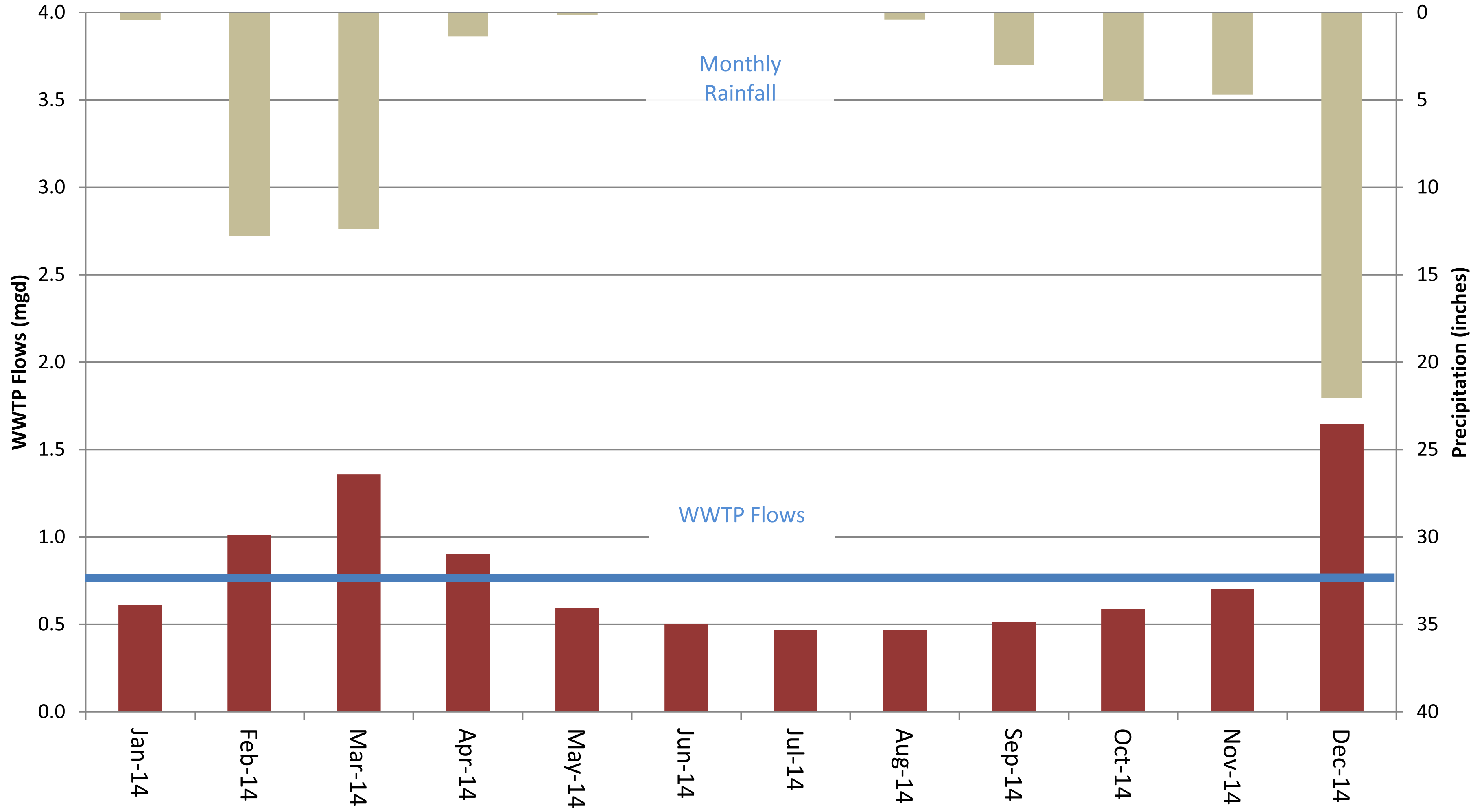
- **Average Annual Flow (AAF).** The average annual flow is the total annual flow, or average monthly flow, for a given year, expressed in daily or other time units. This flow includes the combined average of the average dry weather flow (ADWF) and average wet weather flow (AWWF).

- **Average Dry Weather Flow (ADWF).** The average dry weather flow occurs on a daily basis during the dry weather season, with no evident reaction to rainfall. The ADWF also includes the Base Wastewater Flow (BWF). The base wastewater flow is the average flow that is generated by residential, commercial, and industrial users. The flow pattern from these users varies depending on land use types.

- **Average Wet Weather Flow (AWWF).** This average wet weather flow occurs on a daily basis during the wet weather season. In addition to the flow components in the ADWF, the AWWF includes infiltration and inflow from storm rainfall events.

- **Maximum Month Dry Weather Flow (MMDWF).** This maximum month flow occurs during the dry weather season.

- **Maximum Month Wet Weather Flow (MMWWF).** This maximum month flow occurs during the wet weather season.



LEGEND

Monthly Flows Rainfall

2014 Average Flow

September 28, 2016

Figure 5.1

2014 WWTP Flows

Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

Table 5.1 Historical Wastewater Treatment Plant Flows

Wastewater Master Plan
City of Shasta Lake

Year	Average Annual Flow	Seasonal Average		Maximum Month				Maximum Day					Peak Hour			
				MMDWF		MMWWF		MDDWF		MDWWF			PHDWF		PHWWF	
		ADWF	AWWF	Flow	Month of Occurrence	Flow	Month of Occurrence	Flow	Day of Occurrence	Flow	Day of Occurrence	Previous Week	Flow	Day of Occurrence	Flow	Day of Occurrence
	(MGD)	(MGD)	(MGD)	(MGD)		(MGD)		(MGD)		(MGD)		(in)	(MGD)		(MGD)	
2004	1.01	0.69	1.08	0.69	August	1.74	February	0.84	August 23	3.36	February 17	8.2	---	---	---	---
2005	1.05	0.74	1.11	0.79	July	1.65	December	0.99	July 16	4.19	December 31	11.7	---	---	---	---
2006	1.07	0.69	1.15	0.70	August	1.68	March	0.92	July 8[4]	3.45	January 2	11.6	1.20	July 7	3.65	January 1
2007	0.88	0.68	0.92	0.69	July	1.47	February	0.91	July 19	4.06	February 11	5.9	---	---	---	---
2008	0.92	0.66	0.97	0.68	July	1.52	February	0.87	July 6	3.14	February 3	5.1	---	---	---	---
2009	0.90	0.64	0.96	0.65	July	1.43	February	0.77	August 2	2.67	February 24	6.5	---	---	---	---
2010	1.03	0.65	1.12	0.66	July	1.70	January	0.75	July 12	2.99	January 22	10.7	---	---	---	---
2011	0.91	0.66	0.96	0.70	July	1.71	March	0.88	July 1	2.95	March 27	7.0	---	---	---	---
2012	0.88	0.56	0.94	0.57	July	1.71	December	0.65	August 20	2.88	December 24	6.7	---	---	---	---
2013	0.71	0.57	0.74	0.59	July	1.00	April	0.74	July 1	1.73	April 5	3.3	---	---	---	---
2014	0.78	0.47	0.84	0.47	July	1.65	December	0.54	August 18	3.13	December 12	9.6	0.80	August 17	5.00[5]	December 12
Historical Peaking Factors (applied to ADWF)																
2004	1.47	1.00	1.56	1.00		2.53		1.22		4.88			---		---	
2005	1.41	1.00	1.50	1.06		2.23		1.33		5.64			---		---	
2006	1.55	1.00	1.66	1.01		2.44		1.33		5.00			1.74		5.29	8.40
2007	1.30	1.00	1.36	1.02		2.18		1.35		6.01			---		---	
2008	1.38	1.00	1.46	1.02		2.29		1.31		4.73			---		---	
2009	1.42	1.00	1.50	1.02		2.24		1.21		4.18			---		---	
2010	1.58	1.00	1.72	1.02		2.61		1.15		4.60			---		---	
2011	1.37	1.00	1.45	1.06		2.58		1.33		4.46			---		---	
2012	1.56	1.00	1.67	1.01		3.04		1.15		5.10			---		---	
2013	1.25	1.00	1.30	1.03		1.77		1.30		3.05			---		---	
2014	1.66	1.00	1.80	1.00		3.52		1.15		6.68			1.71		10.66	
Peaking Factor Analysis																
10-Year Average		1.00	1.54	1.03		2.49		1.26		4.95			---		---	
10-Year Maximum		1.00	1.80	1.06		3.52		1.35		6.68			---		---	
5-Year Average		1.00	1.59	1.02		2.70		1.22		4.78						
5-Year Maximum		1.00	1.80	1.06		3.52		1.33		6.68			1.12		3.41	
Last Year		1.00	1.80	1.00		3.52		1.15		6.68			1.71		10.66	
Recommended Factor		**1.00**	**1.75**	**1.00**		**3.00**		**1.35**		**6.00**						

Notes:

5/6/2016

1. Definitions are as follows:
   - AAF - Average Annual Flow (annual flow, expressed in daily or other time units)
   - ADWF - Average Dry Weather Flow (average flow that occurs on a daily basis during the dry weather season)
   - AWWF - Average Wet Weather Flow (average flow that occurs on a daily basis during the wet weather season)
   - MMDWF - Maximum Month Dry Weather Flow (maximum month flow during the dry weather season)
   - MMWWF - Maximum Month Wet Weather Flow (maximum month flow during the wet weather season)
   - MDDWF - Maximum Day Dry Weather Flow (highest measured daily flow that occurs during a dry weather season)
   - MDWWF - Maximum Day Wet Weather Flow (highest measured daily flow that occurs during a wet weather season)
2. Based on historical rainfall data, the dry weather season is taken to be the months of July and August. All other months considered part of the wet weather season.
3. March 2010 flow data was unusable and not included in the historical flow tabulation.
4. The MDDWF for 2006 occurred on August 29. However, according to City staff per conversation October 26, 2015, the recorded value of 1.26 MGD was an anomaly due to mechanical failure; the next highest MDDWF is shown above.
5. The peak hour flow during the 2014 wet weather event exceeded the operating range of the data recorder for approximately 3 hours; therefore the value shown is the maximum recordable value, not necessarily the actual peak hour wet weather flow.

- **Maximum Day Dry Weather Flow (MDDWF).** This is the highest measured daily flow that occurs during a dry weather season.

- **Maximum Day Wet Weather Flow (MDWWF).** This is the highest measured daily flow that occurs during a wet weather season.

- **Peak Dry Weather Flow (PDWF).** This is the highest measured hourly flow that occurs during a dry weather season.

- **Peak Wet Weather Flow (PWWF).** This is the highest measured hourly flow that occurs during a wet weather season.

Table 5.1 shows the flows experienced at the Shasta Lake WWTP have decreased from 0.69 MGD in 2004 (ADWF) to 0.47 MGD (ADWF) in 2014, which represents a decrease of approximately 32%.

In addition to listing the 2004-2014 flows, and for comparison purposes, the table calculates the peaking factors applied to the corresponding average dry weather flows for each year. During wet weather flows, the maximum daily volume (MDWWF) experienced at the Shasta Lake WWTP was up to 6.7 times higher than the average dry weather flow. The maximum hourly peak flow (PWWF) experienced at the Shasta Lake WWTP was up to 10.7 times higher than the average dry weather flow. Table 5.2 shows a selected number of annual peak flow events experienced at the WWTP; for each peak flow event shown the previous week and peak day rainfall volumes are included, along with the corresponding recurrence interval for the peak day rainfall volume.

5.2 EXISTING WASTEWATER FLOWS BY COLLECTION BASIN

The existing wastewater flows represented in this master plan were based on the City's billing records. The number of developed acres and corresponding wastewater flows, for each wastewater collection basin, are summarized on Table 5.3. These basins correspond to wastewater collection trunk systems as discussed in Chapter 4.

- **Basin 1.** This basin includes 4 percent of the total developed acres and 5 percent of the existing dry weather flows.

- **Basin 2.** This basin includes 0.2 percent of the total developed acres and 0.2 percent of the existing dry weather flows.

- **Basin 3.** This basin includes 21 percent of the total developed acres and 24 percent of the existing dry weather flows.

- **Basin 4.** This basin includes 24 percent of the total developed acres and 15 percent of the existing dry weather flows.

- **Basin 5.** This basin includes 46 percent of the total developed acres and 45 percent of the existing dry weather flows.

Table 5.2 Peak Flow Events

Wastewater Master Plan
City of Shasta Lake

Event Date		Previous Week Rainfall[1,2]			Flow			Peak Hour Factor[3]
			Maximum Day					
Year	Day	7-Day Total (in)	Total (in)	Estimated Return Period	Average Annual (mgd)	Maximum Day (mgd)	Peak Hour (mgd)	
2006	January 1	11.6	3.9	1 Year - 24 Hour	1.07	1.94	3.65	1.88
	July 7	0.0	0.0	-		0.88	1.20	1.14
2007	January 22	0.0	0.0	-	0.88	0.94	2.75	2.93
	August 10	0.0	0.0	-		0.61	1.45	2.38
2014	December 12	9.6	7.6	10 Year - 24 Hour	0.78	2.61	5.00[4]	1.92
	August 17	0.0	0.0	-		0.54	0.80	1.48

Notes:

7/20/2016

1. Rainfall totals and return period estimated based on weighted average of 24-hour rainfall totals measured at the following NOAA Rain Stations: 04-8135, 04-9621, 04-7296, 04-1149.
2. Rainfall totals for NOAA rain stations extracted from Department of Water Resources California Data Exchange Center.
3. Peak Hour Factor = Peak Hour Flow / Maximum Day Flow.
4. The peak hour flow during the 2014 wet weather event exceeded the operating range of the data recorder for approximately 3 hours; therefore the value shown is the maximum recordable value, not necessarily the actual peak hour wet weather flow.

Table 5.3 Existing Average Dry Weather Flows by Basin

Wastewater Master Plan

City of Shasta Lake

Basin	Area[1]		Average Dry Weather Flows	
	Acres	Percent of Total	Flows	Percent of Total
	(net acre)	(%)	(mgd)	(%)
1	61	4%	0.033	5%
2	3	0.2%	0.001	0.2%
3	298	21%	0.149	24%
4	343	24%	0.097	15%
5	665	46%	0.282	45%
6	72	5%	0.067	11%
Total	1,442	100%	0.63	100%

Note:

1. Area shown represents developed parcels within the service area excluding non-flow generating parcels.

- **Basin 6.** This basin includes 5 percent of the total developed acres and 11 percent of the existing dry weather flows.

5.3 BUILDOUT WASTEWATER FLOWS

For planning purposes, City staff indicated that potential development over the next ten years is expected to occur in Focus Areas 4A, 4B, 4L, and 1D. Accordingly, the future system improvements for the ten-year planning horizon were sized to accommodate flows from those four focus areas, as well as a small number of septic accounts located on the boundaries of the existing service area.

The 20-year planning horizon included additional development in Focus Areas 1A, 1B, 1C, 1E and 1F. In addition to the buildout of these focus areas, improvements were recommended to accommodate the buildout of the Mountain Gate development, north of Shasta Dam Boulevard and west of Cascade Boulevard.

Flows for the projected developments described previously were based on their respective land use and corresponding flow factors and are documented on **Table 5.4**. Annual wastewater flow projections, based on the population and a unit flow factor of 67 gallons per day per capita (gpdc) are documented on **Table 5.5**. This table documents the service area population projection at a rate of increase of 1.0%, from 2015 (9,403 people) to the planning horizon of 2035 (11,473 people).

5.4 WASTEWATER COLLECTION SYSTEM DESIGN FLOWS

The design flows most relevant in this capacity analysis of the wastewater collection system, in addition to the Maximum Day Dry Weather Flows (MDDWF), include the peak dry weather flow (PDWF) and peak wet weather flow (PWWF).

- **Peak Dry Weather Flow (PDWF).** The PDWF is used for evaluating the capacity adequacy of the wastewater collection system, and to meet the criteria set forth in the previous chapter and in the City standards.

- **Peak Wet Weather Flow (PWWF).** The PWWF is used for designing the capacity of the collection system, while allowing acceptable amounts of surcharging in the system. During PWWF a relaxed criteria was used compared to PDWFs. The hydraulic analysis allowed surcharging to occur during wet weather conditions with the hydraulic grade line (HGL) rising up to three foot below the manhole rim. If the HGL at any time was less than three feet from the manhole rim, the pipe was considered deficient.

The design flows used in evaluating the capacity adequacy of the wastewater collection system are summarized on **Table 5.6**. The table lists the PDWF and PWWF flows used under existing conditions as well as buildout of the 10-year and 20-year planning horizons.

Table 5.4 Future Development ADWF
Wastewater Master Plan
City of Shasta Lake

Growth Focus Area	Average Dry Weather Flows		
	Residential (mgd)	Non-Residential (mgd)	Subtotal (mgd)
10-Year Planning Horizon			
4A	-	0.024	0.024
4B	0.001	0.018	0.019
4L	0.031	-	0.031
1D	-	0.023	0.023
Total	**0.032**	**0.065**	**0.097**
20-Year Planning Horizon			
1A	0.000	0.010	0.011
1B	0.001	0.008	0.008
1C	0.001	0.003	0.005
1E	0.003	0.003	0.006
1F	-	0.006	0.006
Mountain Gate	-	0.335	0.335
Total	**0.006**	**0.365**	**0.371**

Note: 10/20/2016

1. Dashed value indicates a value of zero for future residential and non-residential average dry weather flow.

Table 5.5 Projected Population and ADWF
Wastewater Collection System Master Plan
City of Shasta Lake

Year	Population[1]	Percent Growth (%)	Average Dry Weather Flow (mgd)
Historical			
2010	9,033	-	-
2011	9,006	-0.3%	-
2012	9,094	1.0%	-
2013	9,311	2.4%	-
2014	9,359	0.5%	-
2015	9,403	0.5%	-
Projected			
2016	9,497	1.0%	0.64
2017	9,592	1.0%	0.64
2018	9,688	1.0%	0.65
2019	9,785	1.0%	0.66
2020	9,883	1.0%	0.66
2021	9,981	1.0%	0.67
2022	10,081	1.0%	0.68
2023	10,182	1.0%	0.68
2024	10,284	1.0%	0.69
2025	10,387	1.0%	0.70
2026	10,491	1.0%	0.70
2027	10,595	1.0%	0.71
2028	10,701	1.0%	0.72
2029	10,808	1.0%	0.72
2030	10,916	1.0%	0.73
2031	11,026	1.0%	0.74
2032	11,136	1.0%	0.75
2033	11,247	1.0%	0.75
2034	11,360	1.0%	0.76
2035	**11,473**	1.0%	**0.77**

Note: 9/6/2016

1. Historical Populations per California Department of Finance estimates, excluding estimated Summit City Population.
2. Projected population excludes Summit City and assumes an annual growth rate of 1.0%.
3. Projected ADWF calculated assuming a per-capita flow of approximately 67 gpcd.

Table 5.6 Design Flows

Wastewater Master Plan

City of Shasta Lake

Description	Peak Dry Weather Flow (mgd)	Peak Wet Weather Flow (mgd)
Existing	2.1	4.8
10-Year Planning Horizon	2.3	5.1
20-Year Planning Horizon	3.0	6.8

10/20/2016

CHAPTER 6 - HYDRAULIC MODEL DEVELOPMENT

This chapter describes the development and calibration of the City's wastewater collection system hydraulic model. Hydraulic network analysis has become an effectively powerful tool in all aspects of wastewater collection system planning, design, operation, management, and system reliability analysis. The City's hydraulic model was used to evaluate the capacity adequacy of the existing system and to plan its expansion to service anticipated future growth.

6.1 HYDRAULIC MODEL SOFTWARE SELECTION

The City's hydraulic model combines information on the physical characteristics of the wastewater collection system (pipelines, lift stations) and operational characteristics (how they operate). The hydraulic model then performs calculations and solves series of equations to simulate flows in pipes, including backwater calculations for surcharged conditions.

There are several network analysis software products released by different manufacturers that can equally perform the hydraulic analysis satisfactorily. The selection of a particular software depends on user preferences, the wastewater collection system's unique requirements, and the costs for purchasing and maintaining the software.

The hydraulic modeling software used for evaluating the capacity adequacy of the City wastewater collection system, InfoSewer by Innovyze Inc., uses the simplified St. Venant's equation, which is utilized to simulate backwater and surcharge conditions, in addition to simulating manifolded force mains. The software also incorporates the use of the Manning Equation in other calculations including upstream pipe flow conditions. The St Venant's and Manning's equations are discussed in the System Performance and Design Criteria chapter.

6.2 HYDRAULIC MODEL DEVELOPMENT

Computer modeling requires the compilation of large numerical databases that enable data input into the model. Detailed physical aspects, such as pipe size, ground elevation, invert elevations, and pipe lengths contribute to the accuracy of the model.

Pipes and manholes represent the physical aspect of the system within the model. A manhole is a computer representation of a place where wastewater flows may be allocated into the hydraulic system, while a pipe represents the conveyance aspect of the wastewater flows. In addition, selected lift station capacity and design head settings were also included into the hydraulic model.

Developing the hydraulic model included system skeletonization, digitizing and quality control, developing pipe and manhole databases, and wastewater loading allocation.

6.2.1 Skeletonization

Skeletonizing the model refers to the process where pipes not essential to the hydraulic analysis of the system are stripped from the model. Skeletonizing the model is useful in creating a system that accurately reflects the hydraulics of the pipes within the system. In addition, skeletonizing the model will reduce complexities of large models, which will also reduce the time of analysis while maintaining accuracy, but will also comply with the limitations imposed by the computer program.

In the City's case, skeletonizing was necessary to reduce the model from approximately 1,200 pipes extracted from the GIS to 300 pipes. The modeled pipes included pipes 6-inches in diameter and larger.

Table 4.1 lists the wastewater collection system total length of gravity pipes at 54 miles, compared to **Table 6.1** listing the total length of modeled gravity pipes at 14 miles. Thus, approximately 25 percent of the total length of gravity pipes was modeled. The modeled wastewater collection system is shown on **Figure 6.1**.

6.2.2 Digitizing and Quality Control

City staff maintains a GIS record of the wastewater collection system. The City has recently completed a system-wide closed-circuit television (CCTV) program for sewer mains, and some manhole field survey information such as rim elevations, pipe invert elevations, as well as the physical manhole location. This GIS data was the basis for developing the hydraulic model used in the capacity evaluation of the wastewater collection system.

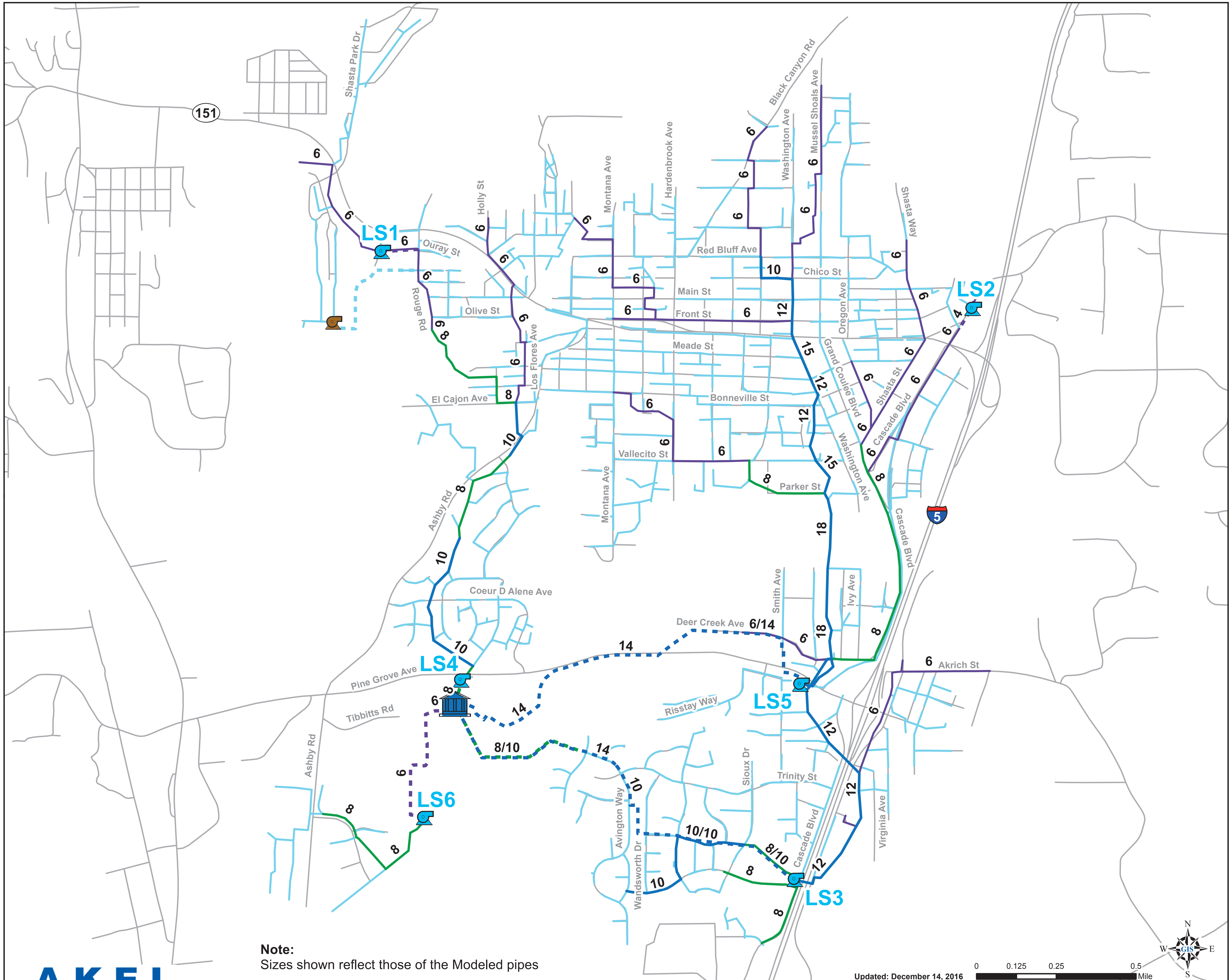
During the development of the new hydraulic model, the project team consisting of City staff and Akel Engineering staff implemented a thorough quality control program to resolve discrepancies. The quality control program included the following:

- The previous hydraulic model, used in the 2005 master plan
- Supplemental field surveys
- Available CCTV

6.2.3 Load Allocation

Load allocation consists of assigning wastewater flow to the appropriate manholes (nodes) in the model. The goal is to distribute the loads throughout the model to best represent actual system response.

Allocating loads to manholes within the hydraulic model required multiple steps, incorporating the efficiency and capabilities of GIS and the hydraulic modeling software. Determining the wastewater loads was accomplished by using addresses in the water consumption billing records and geocoding individual wastewater flows to locations throughout the hydraulic model. These individual loads were allocated to the nearest manhole that serves the corresponding parcel using the capabilities that the hydraulic model has for allocating loads.



Legend

Existing System

- WWTP
- Modeled Lift Stations
- Private Lift Station

Modeled Force Mains

- 6" or Smaller
- 8"
- 10" or Larger

Modeled Gravity Mains

- 6" or Smaller
- 8"
- 10" or Larger

Non-Modeled

- Private Force Mains
- Gravity Mains
- Street Centerlines

Figure 6.1
Existing Modeled Wastewater Collection System
Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

File Path: P:\xGIS\GIS_Projects\Shasta_Lake\Final-HC\COSL_Fig6-1_ModeledSystem_121416.mxd

Table 6.1 Existing Modeled Pipe Inventory
Wastewater Master Plan
City of Shasta Lake

Pipe Size (in)	Modeled Pipe Length (ft)	(miles)
Gravity Mains		
6	36,420	6.9
8	16,715	3.2
10	7,814	1.5
12	5,954	1.1
15	2,329	0.4
18	2,830	0.5
21	673	0.1
Subtotal	72,734	13.8
Force Mains		
4	421	0.1
6	3,322	0.6
8	3,082	0.6
10	6,880	1.3
14	8,055	1.5
Subtotal	21,760	4.1
Total		
	94,494	**17.9**

5/6/2016

6.3 MODEL CALIBRATION

Calibration is intended to instill a level of confidence in the flows that are simulated, and it generally consists of comparing model predictions to the influent wastewater flow recorded at the WWTP, and making necessary adjustments.

6.3.1 Calibration Plan

Calibration can be performed for steady state conditions, which model the peak hour flows, or for dynamic conditions (24 hours or more). Dynamic calibration consists of comparing the model predictions to diurnal operational changes in the wastewater flows. The City's hydraulic model was calibrated for dynamic conditions.

In sanitary sewer systems, and when using dynamic hydraulic modeling to evaluate the impact of wet weather flows, it is common practice to calibrate the model to the following three conditions:

- Peak dry weather flows.
- Peak wet weather flows from storm rainfall Event No. 1.
- Peak wet weather flows from storm rainfall Event No. 2.

After the model is calibrated to these conditions, it is benchmarked and used for evaluating the capacity adequacy of the wastewater collection system, under dry and wet weather conditions.

6.3.2 Dynamic Model Calibration

The calibration process was iterative as it involved calibrating the model for the three calibration conditions: 1) peak dry weather flow, 2) peak wet weather flows from storm rainfall Event No. 1, and 3) peak wet weather flows from storm rainfall Event No. 2.

The rain events of December 31, 2005 (Event No. 1) and December 31, 2014 (Event No. 2), as listed on **Table 3.4**, were used to calibrate the hydraulic model to the wet weather conditions. The calibration effort continued until it yielded acceptable results for each of the three calibration conditions.

The calibration results for are documented in **Appendix A**. These results indicate the calibration effort yielded reasonable comparisons between the flow monitoring data and the hydraulic model predictions at WWTP. After each of the calibration process has been completed, the hydraulic model was benchmarked for further analysis and evaluation.

6.3.3 Use of the Calibrated Model

The calibrated hydraulic model was used as an established benchmark in the capacity evaluation of the existing wastewater collection system. The model was also used to identify improvements necessary for mitigating existing system deficiencies and for accommodating future growth. The hydraulic model is a valuable investment that will continue to prove its worth to the City as future planning issues or other operational conditions surface. It is recommended that the model be maintained and updated with new construction projects to preserve its integrity.

6.4 PROPOSED FLOW MONITORING PROGRAM

While flow monitoring not included as part of this study, the City requested Akel Engineering Group recommend locations for potential future flow monitors. **Figure 6.2** and **Table 6.2** document these recommended flow monitor locations. These flow monitors are intended to capture the existing tributary basins within the City, and also to provide assistance in evaluating lift station performance in the absence of SCADA data. A schematic of how each basin contributes flow to the recommended sites in shown graphically on **Figure 6.3**.

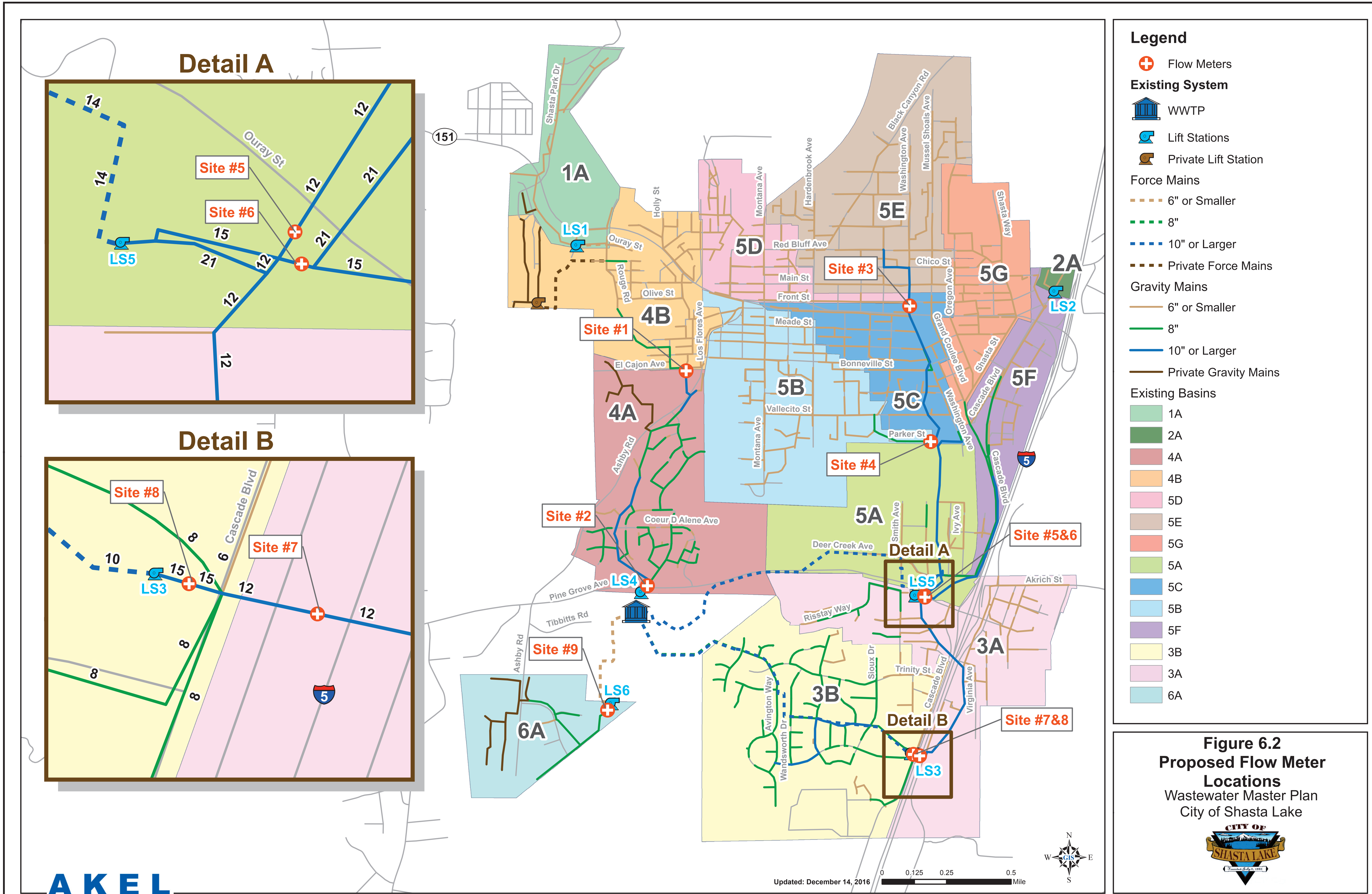
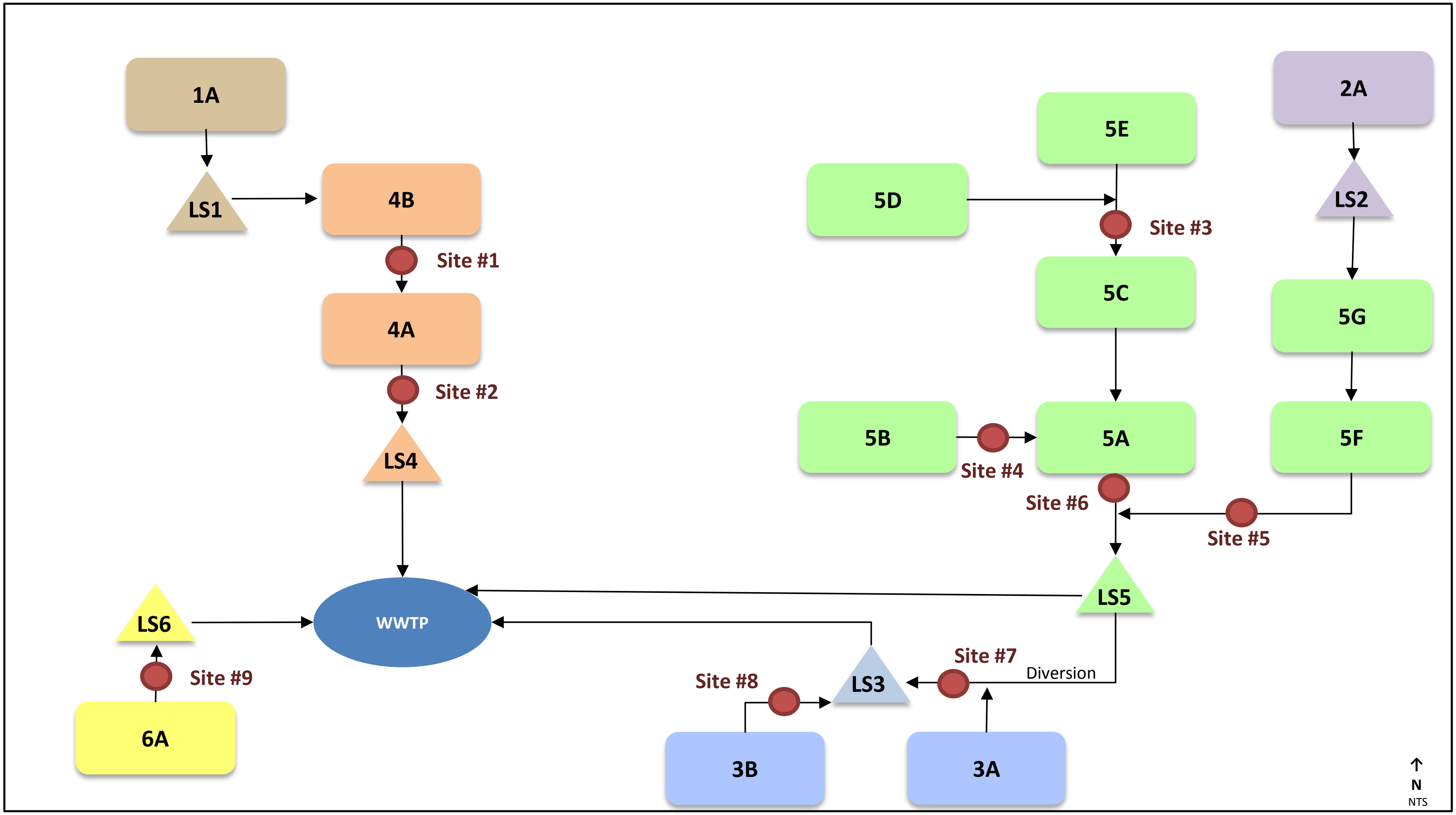


Figure 6.2
Proposed Flow Meter Locations
Wastewater Master Plan
City of Shasta Lake



LEGEND

Wastewater Tributary Area

Recommended Flow Monitoring Site

Wastewater Lift Station

Wastewater Trunks

August 17, 2016

Figure 6.3

Flow Monitoring Basins

Wastewater Master Plan

City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

Table 6.2. Proposed Flow Monitor Locations

Wastewater Master Plan
City of Shasta Lake

Site ID	Location Description	Pipe Size (in)	Manhole ID
1	Approximately 350' west of the intersection of El Cajon Ave and Ashby Rd	10" S	K16
2	Pine Grove Ave approximately 1,000' west of Coeur D'Alene Ave	8" NE	K16
3	Washington Ave approximately 100' south of Front St	15" S	F35
4	Parker St approximately 600' west of Washington Ave	8" E	D1
5	Pine Grove Ave approximately 220' west of Cascade Blvd	12" NE	F13X
6	Pine Grove Ave approximately 190' west of Cascade Blvd	15" E	F13X
7	Cascade Blvd approximately 120' north of Autumn Harvest Way	12" E	F1
8	Lift Station 3	15" W	F1
9	Approximately 1,000' east of the intersection of Shasta Gateway Dr & Iron Ct	8" NE	T4

8/25/2016

CHAPTER 7 - EVALUATION AND PROPOSED IMPROVEMENTS

This section presents a summary of the wastewater collection system capacity evaluation during peak dry weather flows and peak wet weather flows for the existing and buildout flows. The recommended wastewater collection system improvements needed to mitigate capacity deficiencies are also discussed in this chapter.

7.1 OVERVIEW

The calibrated hydraulic model was used for evaluating the wastewater collection system for capacity deficiencies during peak dry weather flows (PDWF) and peak wet weather flows (PWWF). The criteria used for evaluating the capacity adequacy of the wastewater collection system facilities (gravity mains, force mains, and lift stations) were discussed and summarized Chapter 3.

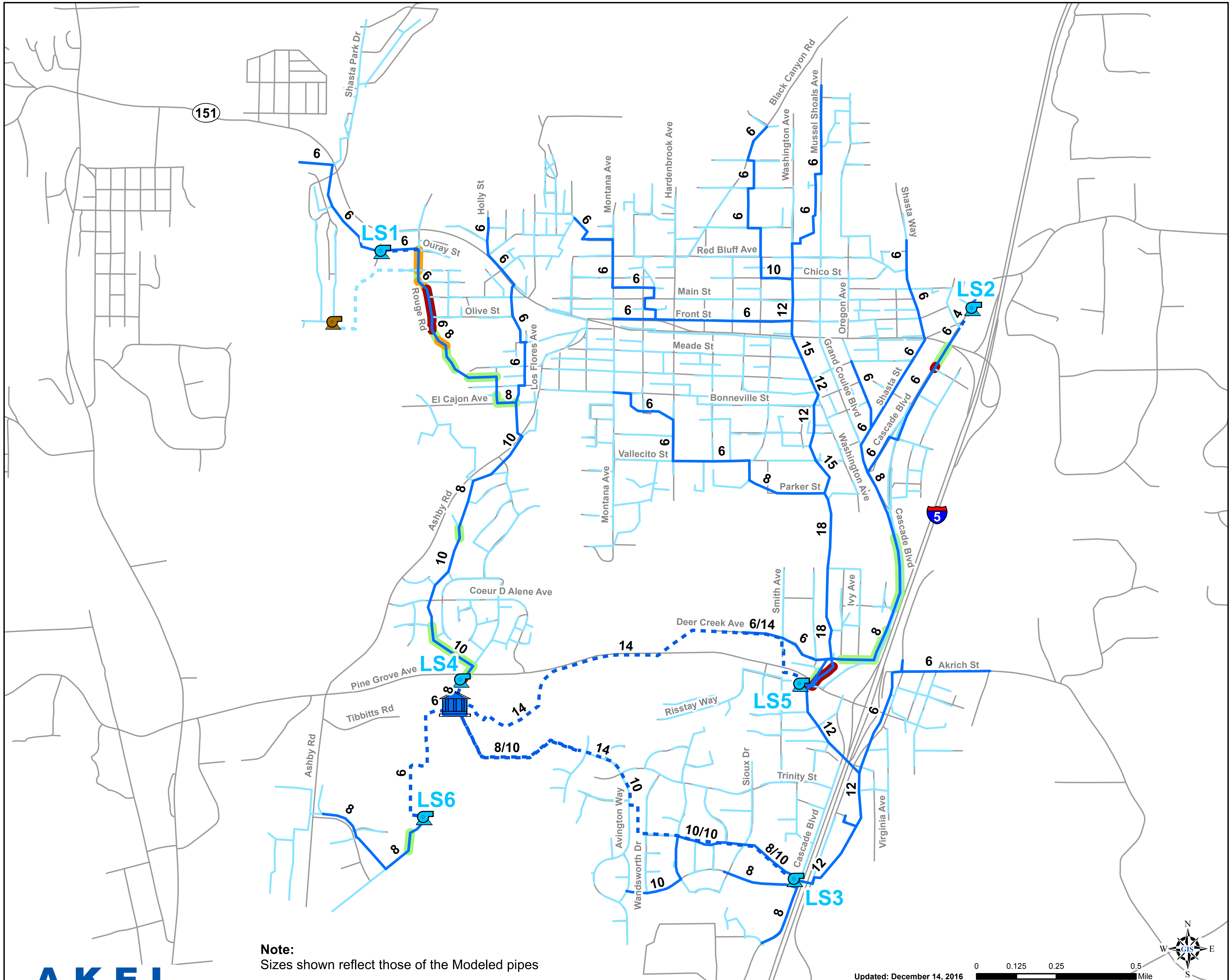
7.2 EXISTING WASTEWATER COLLECTION SYSTEM CAPACITY EVALUATION

The system performance and design criteria, summarized on **Table 3.1**, was thus used as a basis to judge the adequacy of capacity for the existing wastewater collection system. The design flows simulated in the hydraulic model for existing conditions were summarized on **Table 5.6** and they include:

- Existing PDWF = 2.1 MGD
- Existing PWWF = 4.8 MGD

During the peak dry weather simulations, the maximum allowable pipe d/D criteria of 0.75 was used for new pipes. For existing pipes, the criteria was relaxed to allow a maximum d/D ratio of 0.92 (full pipe capacity) to prevent unnecessary pipe replacements. During the peak wet weather simulations, capacity deficiencies included pipe segments with a hydraulic grade line (HGL) that rises within one foot of the manhole rim elevation.

In general, the hydraulic model indicated that the wastewater collection system exhibited acceptable performance to service the existing customers during both peak dry weather flows (**Figure 7.1**) and peak wet weather flows (**Figure 7.2**).



Legend

Analysis Results

Pipe d/D

- d/D > 0.92
- d/D 0.75 - 0.92
- d/D 0.50 - 0.75

Existing System

- WWTP
- Modeled Lift Stations
- Private Lift Station

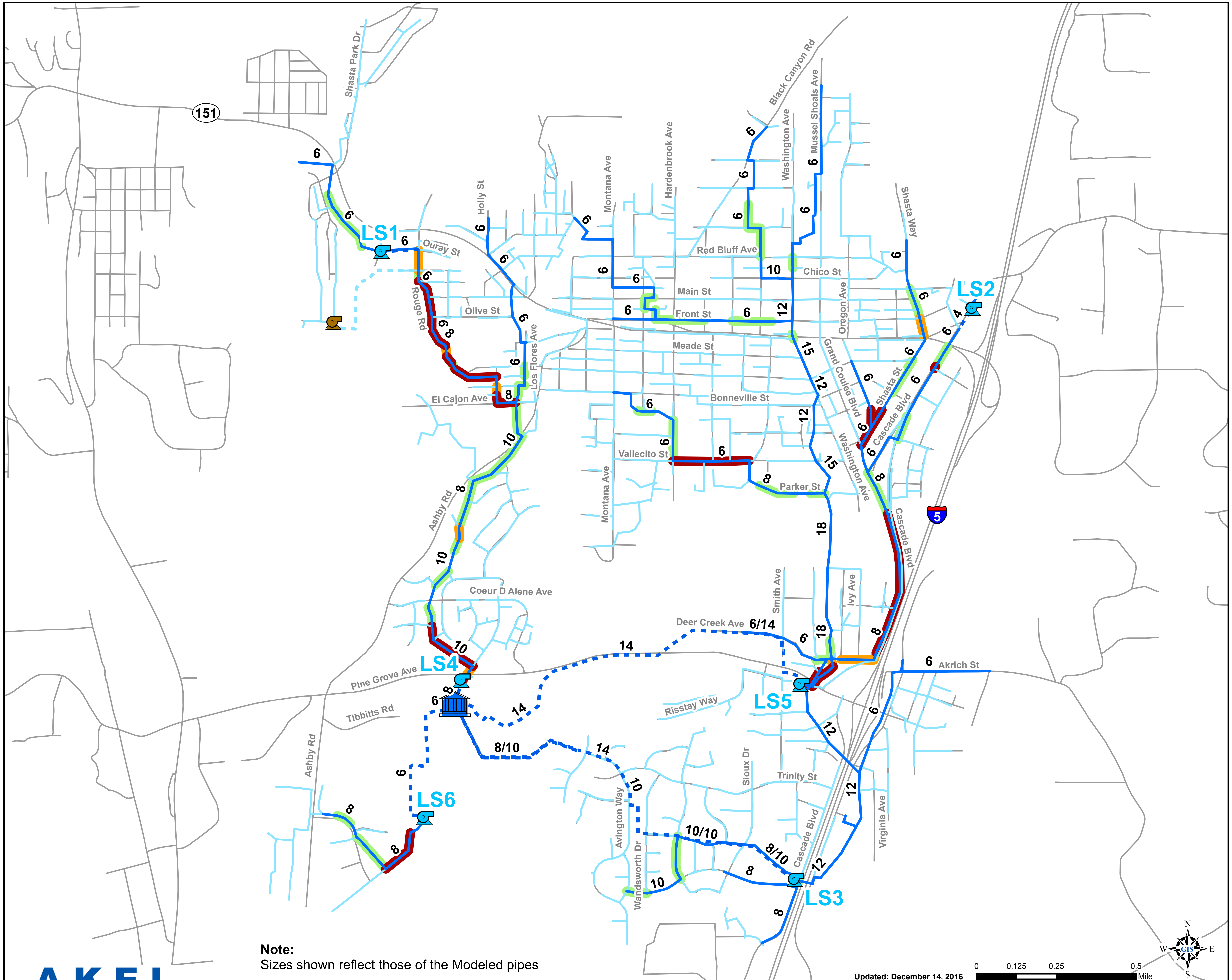
Modeled

- Force Mains
- Gravity Mains

Non-Modeled

- Private Force Mains
- Gravity Mains
- Street Centerlines

Figure 7.1
Existing Modeled System
Analysis for PDWF
Wastewater Master Plan
City of Shasta Lake



Legend

Analysis Results

- Manhole HGL < 3ft of Rim

Pipe d/D

- d/D > 0.92
- d/D 0.75 - 0.92
- d/D 0.50 - 0.75

Existing System

- WWTP
- Modeled Lift Stations
- Private Lift Station

Modeled

- Force Mains
- Gravity Mains

Non-Modeled

- Private Force Mains
- Gravity Mains
- Street Centerlines

Figure 7.2
Existing Modeled System
Analysis for PWWF
Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

File Path: P:\xGIS\GIS_Projects\Shasta_Lake\Final-HC\COSL_Fig7-2_PWWF_121416.mxd

7.2.1 Existing Peak Dry Weather Flows Capacity Evaluation

The design PDWF was estimated at 2.1 MGD, as documented on **Table 5.6**. In general, the hydraulic model indicated that the wastewater collection system exhibited acceptable performance to service the existing customers during peak dry weather flows.

The hydraulic model predicted minor pipe deficiencies in the existing system during peak dry weather flows, as summarized on **Figure 7.1**. These deficiencies are summarized as follows:

- Rogue Road, approximately from Conchas Street to 300 ft south of Olive Street. This segment experiences d/D ratios between 0.90 and 1.00.

7.2.2 Existing Peak Wet Weather Flows Capacity Evaluation

The design PWWF was estimated at 4.8 MGD, as documented on **Table 5.6**. In general, the hydraulic model indicated that the wastewater collection system had some surcharging, but did not exceed the allowable criteria discussed in a previous chapter. Thus, the hydraulic model does not predict pipe deficiencies in the existing system during existing peak wet weather flows.

7.3 CAPACITY IMPROVEMENTS

The system performance and design criteria summarized on **Table 3.1**, was used as a basis to judge the capacity adequacy of the existing wastewater collection system. The design flows simulated in the hydraulic model for the general plan buildout were summarized on **Table 5.6** and they include:

- 10-Year PDWF = 2.3 MGD
- 10-Year PWWF = 5.1 MGD
- 20-Year PDWF = 3.0 MGD
- 20-Year PWWF = 6.8 MGD

During the peak dry weather simulations, the maximum allowable pipe d/D criterion of 0.75 was used for new pipes. For existing pipes, the criterion was relaxed to allow a maximum d/D ratio of 0.92 (full pipe capacity) to prevent unnecessary pipe replacements. During the peak wet weather simulations, capacity deficiencies included pipe segments with a hydraulic grade line (HGL) that rises within one foot of the manhole rim elevation.

The proposed capacity improvements for the wastewater collection system are listed on **Table 7.1**. This table lists the master plan assigned improvement number (e.g., PC-1), along with other relevant information including alignment description, pipe size, pipe length, and a suggested phasing. The proposed improvements are shown with pipe sizes on **Figure 7.3**.

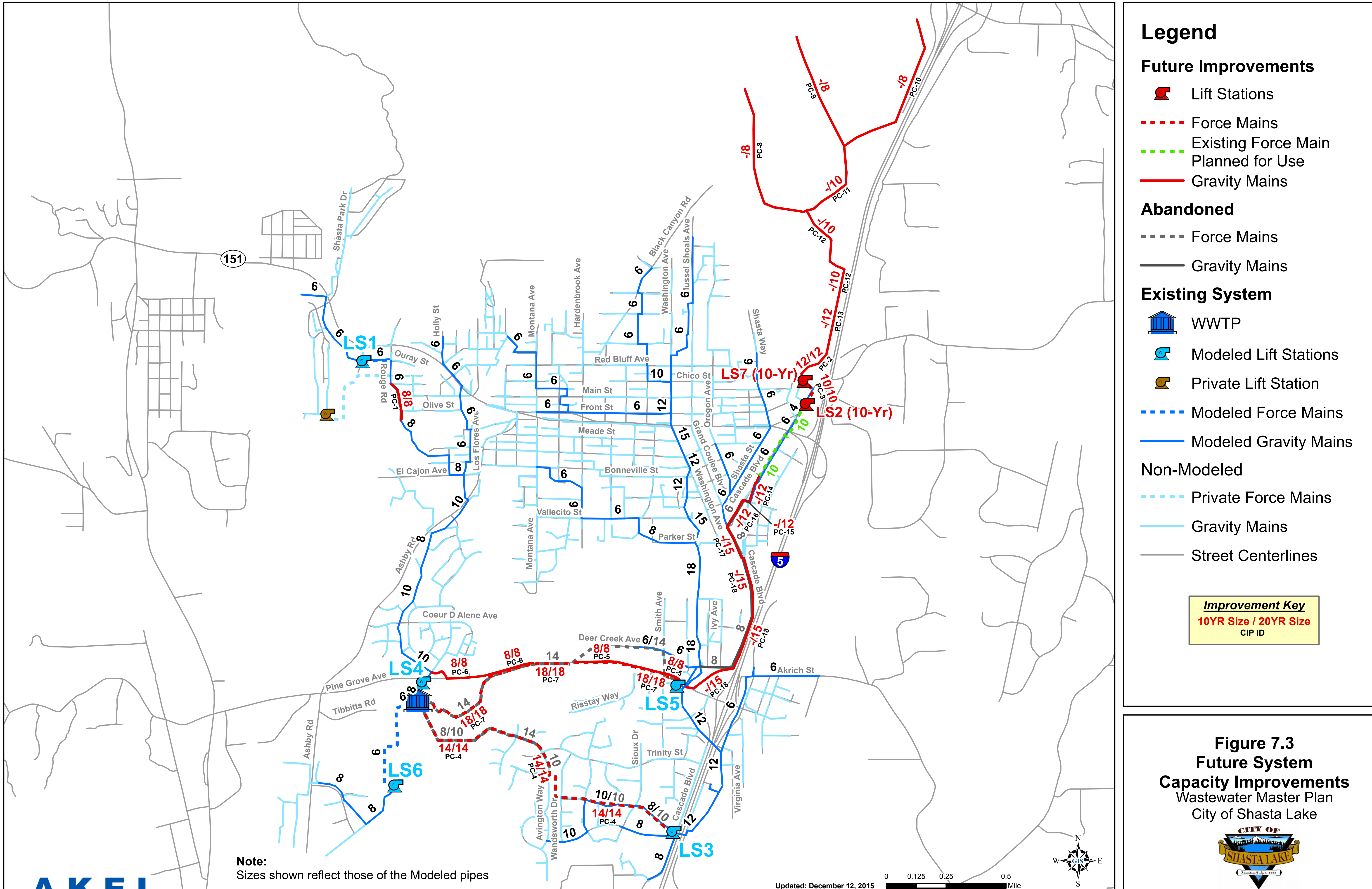


Figure 7.3
Future System
Capacity Improvements
Wastewater Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

File Path: P:\xGIS\GIS_Projects\Shasta_Lake\Final-HC\COSL_Fig7-3_FutureSystem_121216.mxd

Table 7.1 Proposed Capacity Improvements

Wastewater Master Plan
City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/ Suggested Rehabilitation	Infrastructure Costs: Diameter (in)	Infrastructure Costs: Length (ft)	Suggested Phasing
Capacity Improvements								
Pipeline Capacity Improvements								
PC-1	Gravity Main	Rogue Rd	From Conchas St to 240' s/o Olive St	6	Replace	8	950	10 Year
PC-2	Gravity Main	Future ROW	From 1,000' n/o Cascade Blvd to Future LS7	-	New	12	1,300	10 Year
PC-3	Force Main	Future ROW	From LS7 to 270' ne/o intersection of Cascade Blvd and Kennett St	-	New	10	625	10 Year
PC-4	Force Main	Existing ROW	From LS3 to WWTP	8/10/14	Replace	14	7,525	10 Year
PC-5	Gravity Main	Pine Grove Ave	From 1,700' w/o Jorzack Way to 350' w/o Cascade Blvd	-	New	8	2,525	10 Year
PC-6	Gravity Main	Pine Grove Ave	From 1,600' e/o Coeur D'Alene Ave to 800' w/o Coeur D'Alene Ave	-	New	8	2,375	10 Year
PC-7	Force Main	ROW 60' s/o Pine Grove Ave	From LS5 to WWTP	14	Replace	18	6,775	10 Year
PC-8	Gravity Main	ROW	From 4,400' nw/o intersection of Walker Ln and Black Canyon Rd to 4,000' n/o Cascade Blvd	-	New	8	3,550	20 Year
PC-9	Gravity Main	ROW	From 3,700' w/o intersection of HWY-5 and Old Oregon Trl to 4,100' sw/o intersection of HWY-5 and Old Oregon Trl	-	New	8	2,625	20 Year
PC-10	Gravity Main	ROW	From 1,100' w/o intersection of HWY-5 and Old Oregon Trl to 4,100' sw/o intersection of HWY-5 and Old Oregon Trl	-	New	8	3,675	20 Year
PC-11	Gravity Main	ROW	From 4,100' sw/o intersection of HWY-5 and Old Oregon Trl to 4,000' n/o Cascade Blvd	-	New	10	1,900	20 Year
PC-12	Gravity Main	ROW	From 4,000' n/o Cascade Blvd to 1,900' ne/o Cascade Blvd	-	New	10	2,500	20 Year
PC-13	Gravity Main	ROW	From 1,900' ne/o Cascade Blvd to 1,000' n/o Cascade Blvd		New	12	725	20 Year
PC-14	Gravity Main	Cascade Blvd	From Bonneville St to Joseph St	-	New	12	650	20 Year
PC-15	Gravity Main	Joseph St	From Cascade Blvd to Morning Star Way	6	Replace	12	150	20 Year
PC-16	Gravity Main	Morning Star Way	From Joseph St to Grand Coulee Blvd	6	Replace	12	725	20 Year
PC-17	Gravity Main	Grand Coulee Blvd	From Morning Star Way to Cascade Blvd	8	Replace	15	825	20 Year
PC-18	Gravity Main	Cascade Blvd	From Grand Coulee Blvd to Pine Grove Ave	8	Replace	15	3,725	20 Year

12/21/2016

7.3.1 Capacity Improvement Phasing

The Capacity Improvements for the future flows are divided into the following phases:

- **10-Year:** This near-term phase consists of improvements for FY 2016 through FY 2025. These improvements are intended to mitigate existing deficiencies, as well as service future growth.
- **20-Year:** This long-term phase consists of improvements for FY 2026 through FY 2035 that are required to service future growth expected to occur.

This phasing plan is subject to revisions by City staff based on how new developments occur.

7.3.2 10-Year Capacity Improvements

The existing system evaluation revealed pipe capacity deficiencies for existing peak dry weather flow and no pipe capacity deficiencies for the existing peak wet weather flow. **Figure 7.3** shows the improvements necessary to mitigate these existing deficiencies as well as serve future growth, which are summarized as follows:

- Improvement PC-1: Replace the existing 6-inch gravity sewer in Rogue Road from Conchas Street to 240 ft south of Olive Street with a new 8-inch pipe. This improvement is intended to mitigate an existing capacity deficiency.
- Improvement PC-2: Construct a new 12-inch gravity sewer in future right-of-way between 1,000 ft north of Cascade Boulevard to future Lift Station 7. This improvement is intended to service future growth.
- Improvement PC-3: Construct a new 10-inch force main in future right-of-way from future Lift Station 7 to 27- ft northeast of the intersection of Cascade Boulevard and Kennett Street. This improvement is intended to service future growth.
- Improvement PC-4: Replace existing 8-inch, 10-inch, and 14-inch force mains with a new 14-inch force main from Lift Station 3 to the WWTP. This improvement is intended to service future growth, and the final alignment is subject to a potential routing analysis, as determined by City staff and documented in Chapter 4.
- Improvement PC-5: Construct a new 8-inch gravity sewer in Pine Grove Avenue from 1,700 feet west of Jorzack Way to 350 feet west of Cascade Boulevard. Due to steep grades along Pine Grove Avenue this pipeline alignment will require drop manholes, to be approved by the City Engineer. This improvement is intended to service future growth.
- Improvement PC-6: Construct a new 8-inch gravity sewer in Pine Grove Avenue from 1,600 feet east of Coeur D'Alene Avenue to 800 feet west of Coeur D'Alene Avenue. This improvement is intended to service future growth.

- Improvement PC-7: Replace existing 14-inch force main with a new 18-inch force main in right-of-way 60 feet south of Pine Grove Avenue from Lift Station 5 to the WWTP. Final alignment of this improvement is subject to a routing analysis, as determined by City staff and documented in Chapter 4.

7.3.3 20-Year Future Capacity Improvements

The following improvements, shown on **Figure 7.3**, have been identified to serve the long-term growth of the City within FY 2026 to FY 2035.

- Improvement PC-8: Construct a new 8-inch gravity sewer in right-of-way from 4,400 feet northwest of the intersection of Walker Lane and Black Canyon Road to 4,000 feet north of Cascade Boulevard.

- Improvement PC-9: Construct a new 8-inch gravity sewer in right-of-way from 3,700 feet west of the intersection of Highway 5 and Old Oregon Trail to 4,100 feet southwest of the intersection of Highway 5 and Old Oregon Trail.

- Improvement PC-10: Construct a new 8-inch gravity sewer in right-of-way from 1,100 feet west of the intersection of Highway 5 and Old Oregon Trail to 4,100 feet southwest of the intersection of Highway 5 and Old Oregon Trail.

- Improvement PC-11: Construct a new 10-inch gravity sewer in right-of-way from 4,100 feet southwest of the intersection of Highway 5 and Old Oregon Trail to 4,000 feet north of Cascade Boulevard.

- Improvement PC-12: Construct a new 10-inch gravity sewer in right-of-way from 4,000 feet north of Cascade Boulevard to 1,900 feet northeast of Cascade Boulevard.

- Improvement PC-13: Construct a new 12-inch gravity sewer in right-of-way from 1,900 feet northeast of Cascade Boulevard to 350 feet northwest of Cascade Boulevard.

- Improvement PC-14: Construct a new 12-inch gravity sewer in Cascade Boulevard from Bonneville Street to Joseph Street.

- Improvement PC-15: Replace existing 6-inch sewer with a new 12-inch gravity sewer in Joseph Street from Cascade Boulevard to Morning Star Way.

- Improvement PC-16: Replace existing 6-inch sewer with a new 12-inch gravity sewer in Morning Star Way from Joseph Street to Grand Coulee Boulevard.

- Improvement PC-17: Replace existing 8-inch gravity sewer with a new 15-inch gravity sewer in Grand Coulee Boulevard from Morning Star Way to Cascade Boulevard.

- Improvement PC-18: Replace existing 8-inch gravity sewer with a new 15-inch gravity sewer in Cascade Boulevard from Grand Coulee Boulevard to Pine Grove Avenue.

7.4 CONDITION ASSESSMENT IMPROVEMENTS

The City has recently completed a system-wide CCTV assessment of the wastewater collection system, and provided the information as part of this master plan. The CCTV was reviewed to identify additional critical capital improvement projects based on the condition of the pipelines.

The condition of the wastewater pipes was evaluated to identify pipes in poor condition and prioritize improvements. The condition assessment involved CCVTV of wastewater pipes, and which was completed in accordance with the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) standards. This included determining structural, operational and maintenance, construction, and miscellaneous defects.

The CCTV data was imported into Innovyze's InfoMaster, which aids in the graphical representation and ranking of the CCTV results. The purpose of this analysis was to determine the following:

- **Infiltration and Inflow Defects.** These defects can contribute to high infiltration and inflows into the wastewater collection system, which can impact the performance of the collection system and the wastewater treatment plant during intense rainfall events. Infiltration and inflow defects are documented on **Figure 7.4**.

- **Major Structural Defects.** These defects are critical failures of the pipeline, and can consist of broken pipes, holes in the pipe, collapsed pipe, or potential foreign objects protruding into the pipeline and creating capacity or safety concerns. Major structural defects are documented on **Figure 7.5**.

It should be noted that maps were provided to the City early in the master plan evaluation, and City staff have taken initiative to begin correcting these deficiencies immediately. Some of the defects noted on the maps may have been corrected by the publishing of the master plan; however, they are included for cost estimating purposes.

As part of the InfoMaster analysis, improvements were identified that are recommended for immediate and near term. The improvements types associated with the pipeline rehabilitation are documented on **Figure 7.6** and described as follows:

- **Defect Repair:** Pipes identified as having point defects are recommended for repair. Due to the uncertain nature of the point repair, and for estimating purposes, ten feet upstream and ten feet downstream of each defect are assumed in the length of repair.

- **Pipeline Replacement:** Based on the results of the condition assessment it was determined that the replacement of the existing pipe was required to mitigate existing system defects.

- **Infiltration Repair:** Pipelines with significant infiltration and inflow defects are recommended for repair known as cured in place pipe (CIPP).

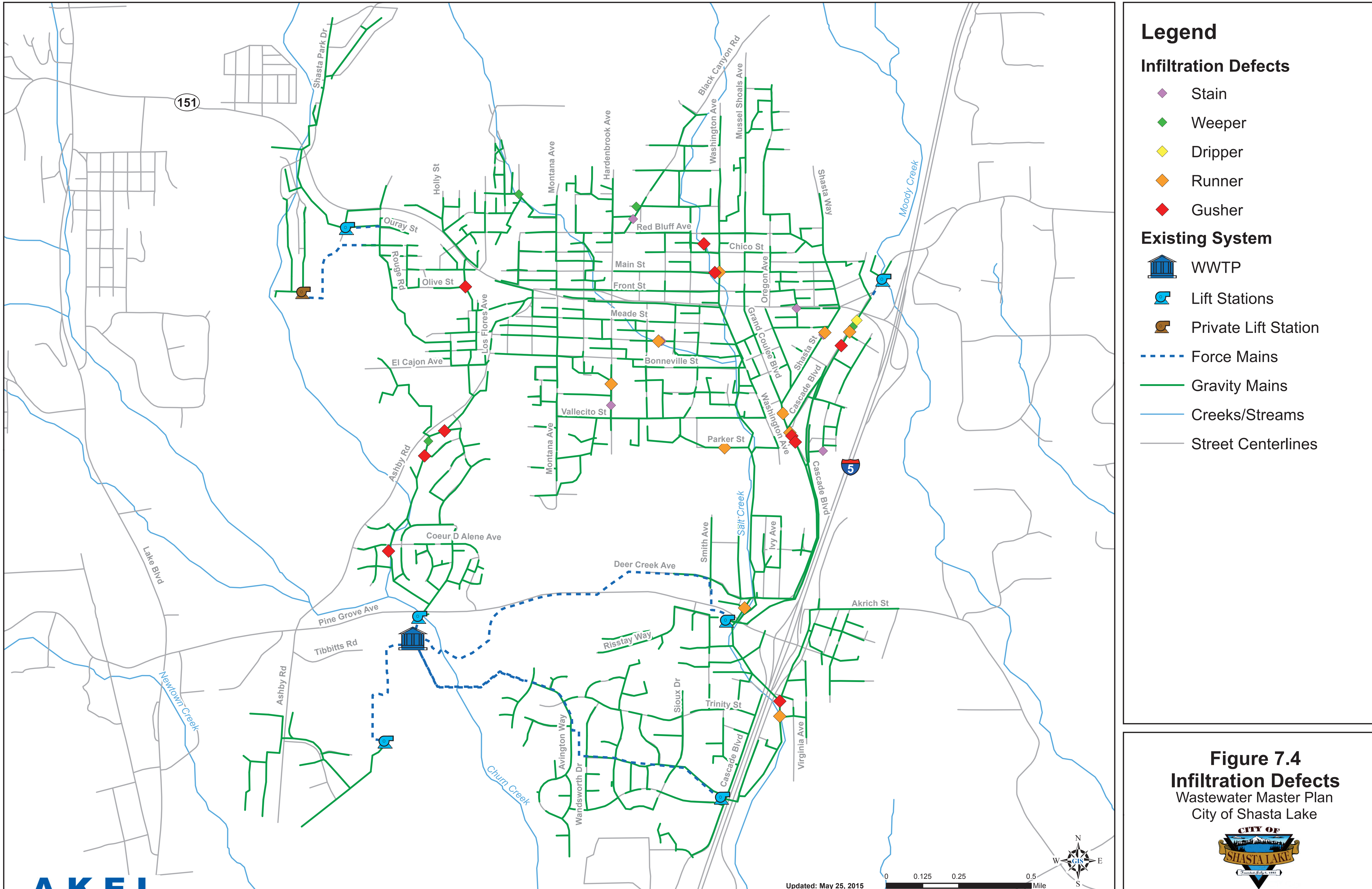
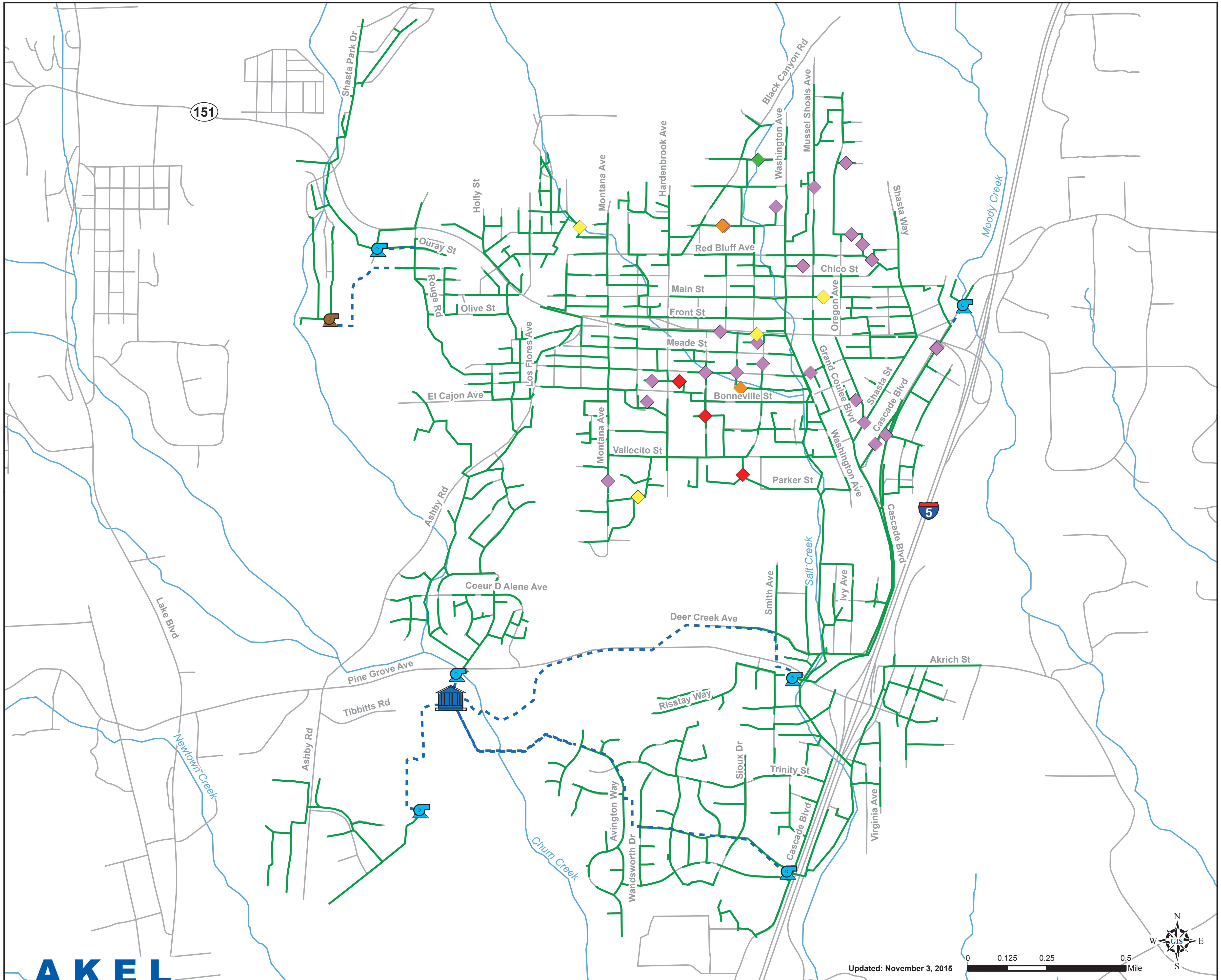


Figure 7.4
Infiltration Defects
Wastewater Master Plan
City of Shasta Lake



Legend

Major Structural Defects

- Broken Pipe
- Broken Pipe - Soil Visible
- Hole in Pipe - Soil Visible
- Objects Intruding into Pipe
- Collapsed pipe

Existing System

- WWTP
- Lift Stations
- Private Lift Station
- Force Mains
- Gravity Mains
- Creeks/Streams
- Street Centerlines

Figure 7.5
Major Structural Defects
Wastewater Master Plan
City of Shasta Lake

AKEL
ENGINEERING GROUP, INC.

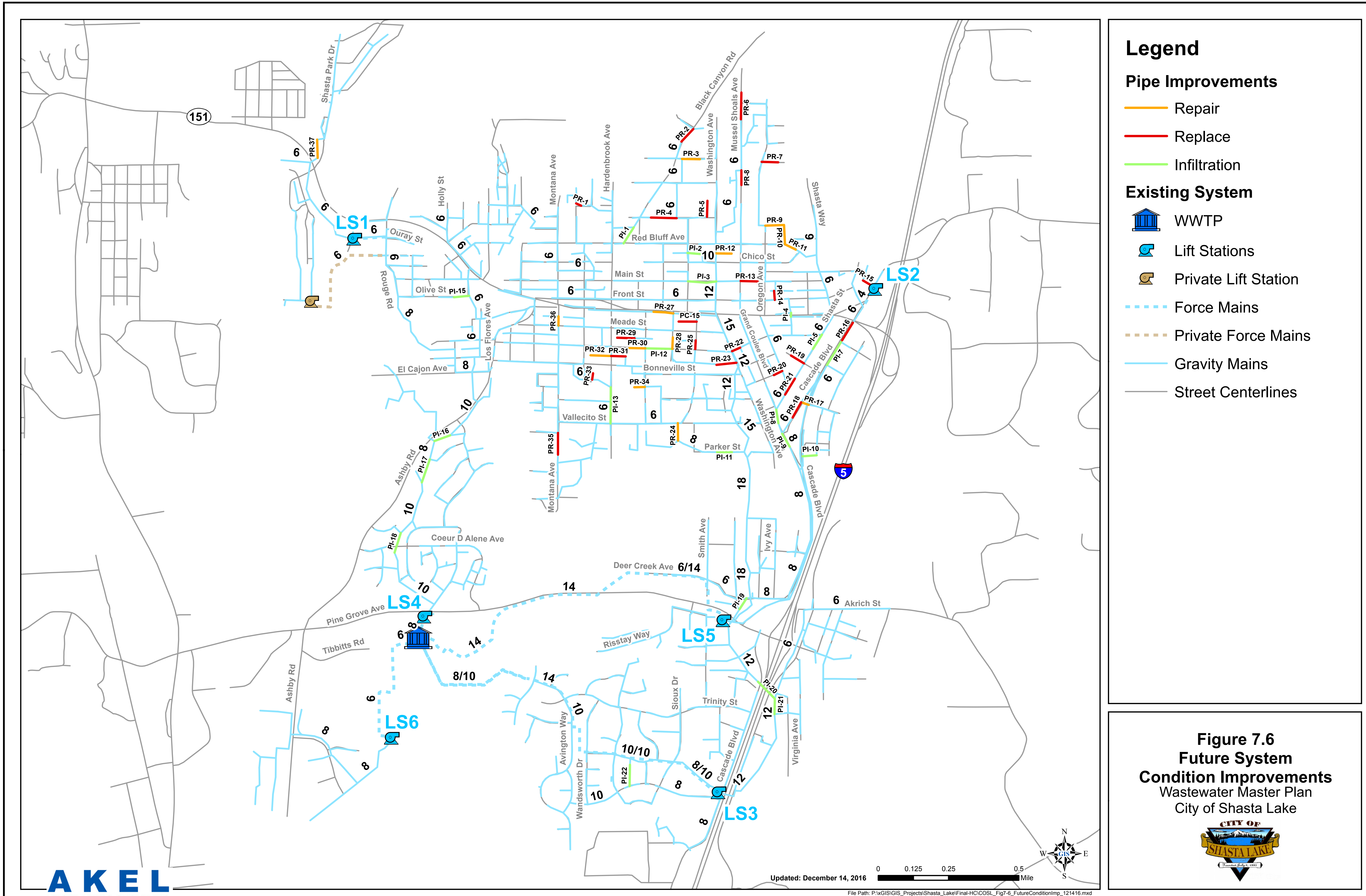


Figure 7.6
Future System
Condition Improvements
Wastewater Master Plan
City of Shasta Lake

7.5 LIFT STATIONS OPERATIONS

The City currently owns and operates six lift stations that convey collected wastewater flows to the WWTP. The maximum and average modeled inflows for each lift station, under PDWF and PWWF conditions are shown on Table 7.2 and are summarized below:

- **Lift Station 1:** The maximum modeled lift station inflow under PDWF and PWWF conditions was 0.08 and 0.19 MGD respectively.
- **Lift Station 2:** The maximum modeled lift station inflow under PDWF and PWWF conditions was 0.002 and 0.009 MGD respectively.
- **Lift Station 3:** The maximum modeled lift station inflow under PDWF and PWWF conditions was 0.39 and 1.07 MGD respectively.
- **Lift Station 4:** The maximum modeled lift station inflow under PDWF and PWWF conditions was 0.46 and 1.01 MGD respectively.
- **Lift Station 5:** The maximum modeled lift station inflow under PDWF and PWWF conditions was 0.97 and 2.38 MGD respectively.
- **Lift Station 6:** The maximum modeled lift station inflow under PDWF and PWWF conditions was 0.16 and 0.37 MGD respectively.

Table 7.3 summarizes the maximum and average inflows of the existing lift stations, under PDWF and PWWF conditions, at the buildout of the 10-year and 20-year planning horizons. At the buildout of the 10-year and 20-year planning horizons, Lift Station 1 and Lift Station 6 are not expected to experience an increase in inflow due to lack of development within the lift station tributary area. The maximum inflows for the remaining lift stations are summarized below:

- **Lift Station 2:** The future modeled lift station inflow under PDWF and PWWF conditions for the 10-year planning horizon was 0.008 and 0.017 MGD respectively. This lift station experiences an increase in flow from the existing conditions due to future commercial development in Focus Subarea 1D.
- **Lift Station 3:** The future modeled lift station inflow under PDWF and PWWF conditions for the 10-year planning horizon was 0.40 and 1.11 MGD respectively. This lift station experiences slight increases in flow from the existing conditions due to future residential development in the tributary area. This lift station is not expected to receive additional inflow at the buildout of the 20-year planning horizon.

Table 7.2 Existing Lift Station Operations

Wastewater Master Plan
City of Shasta Lake

Lift Station	Firm Capacity (mgd)	Wet Well Inflow	
		Maximum (mgd)	Average (mgd)
Peak Dry Weather Flow			
Lift Station 1	0.50	0.078	0.054
Lift Station 2	0.06	0.002	0.002
Lift Station 3	2.40	0.390	0.277
Lift Station 4	1.44	0.464	0.312
Lift Station 5	2.90	0.972	0.676
Lift Station 6	0.31	0.164	0.113
Peak Wet Weather Flow			
Lift Station 1	0.30	0.190	0.105
Lift Station 2	0.06	0.009	0.004
Lift Station 3	2.40	1.074	0.552
Lift Station 4	1.44	1.012	0.561
Lift Station 5	2.90	2.378	1.278
Lift Station 6	0.31	0.374	0.218

10/18/2016

Table 7.3 Future Lift Station Operations

Wastewater Master Plan
City of Shasta Lake

Lift Station	Firm Capacity (mgd)	Wet Well Inflow: 10-Year Planning Horizon Maximum (mgd)	Wet Well Inflow: 10-Year Planning Horizon Average (mgd)	Wet Well Inflow: 20-Year Planning Horizon Maximum (mgd)	Wet Well Inflow: 20-Year Planning Horizon Average (mgd)
Peak Dry Weather Flow					
Lift Station 1	0.50	0.078	0.054	0.078	0.054
Lift Station 2	1.00	0.008	0.006	0.008	0.006
Lift Station 3	2.40	0.397	0.282	0.397	0.282
Lift Station 4	1.44	0.534	0.358	0.534	0.358
Lift Station 5	2.90	1.160	0.810	1.914	1.384
Lift Station 6	0.31	0.164	0.113	0.164	0.113
Lift Station 7	1.60	0.036	0.025	0.844	0.034
Peak Wet Weather Flow					
Lift Station 1	0.50	0.190	0.105	0.190	0.105
Lift Station 2	0.06	0.017	0.010	0.017	0.010
Lift Station 3	2.40	1.104	0.565	1.104	0.565
Lift Station 4	1.44	1.100	0.640	1.100	0.640
Lift Station 5	2.90	2.647	1.542	3.935	2.587
Lift Station 6	0.31	0.374	0.218	0.374	0.218
Lift Station 7	1.60	0.181	0.026	1.544	0.042

10/18/2016

- **Lift Station 4:** The future modeled lift station inflow under PDWF and PWWF conditions for the 10-year planning horizon was 0.53 and 1.10 MGD respectively. This lift station experiences an increase in flow from the existing conditions due to future residential and mixed use development in Focus Subareas 4A, 4B, and 4L. This lift station is not expected to receive additional inflow at the buildout of the 20-year planning horizon.

- **Lift Station 5:** The future modeled lift station inflow under PDWF and PWWF conditions for the 10-year planning horizon was 1.16 and 2.65 MGD respectively. This lift station experiences an increase in flow from the existing conditions due to future residential and mixed use development in Focus Subareas 1D, 4A, 4B, and 4L. The future modeled lift station inflow under PDWF and PWWF conditions for the 20-year planning horizon was 1.91 MGD and 3.94 MGD respectively. The increase in flow from the buildout of the 20-year planning horizon is due to the additional future residential, commercial, and mixed use development in Focus Subareas 1A, 1B, 1C, 1E, and 1F.

- **Future Lift Station 7:** This lift station is intended to convey flow collected from the future Mountain Gate mixed use development. The maximum modeled inflow for Lift Station 7 under PDWF and PWWF conditions for the 10-year planning horizon was 0.04 and 0.18 MGD respectively. Upon the full buildout of the Mountain Gate development at the 20-year planning horizon, the maximum inflow for Lift Station 7 under PDWF and PWWF conditions was 0.84 and 1.54 MGD respectively. It should be noted that these maximum inflows are based on the current development plan. Future flows should be verified with the final development plan, and the lift station sized accordingly.

CHAPTER 8 - CAPITAL IMPROVEMENT PROGRAM

This chapter provides a summary of the recommended Capital Improvement Program (CIP) for the City of Shasta Lake's wastewater collection system. The program is based on the evaluation of the City's wastewater collection system and on the recommended projects described in the previous chapters. The CIP has been prepared to assist the City in planning and constructing the collection system improvements through the ultimate buildout scenario. This chapter also presents the cost criteria and methodologies for developing the capacity improvement costs.

8.1 COST ESTIMATE ACCURACY

Cost estimates presented in the capacity improvement costs were prepared for general master planning purposes and, where relevant, for further project evaluation. Final costs of a project will depend on several factors including the final project scope, costs of labor and material, and market conditions during construction.

The Association for the Advancement of Cost Engineering (AACE International), formerly known as the American Association of Cost Engineers, has defined three classifications. These classifications are presented in order of increasing accuracy: Order of Magnitude, Budget, and Definitive.

- **Order of Magnitude Estimate.** This classification is also known as an "original estimate", "study estimate", or "preliminary estimate", and is generally intended for master plans and studies.

  This estimate is not supported with detailed engineering data about the specific project, and its accuracy is dependent on historical data and cost indices. It is generally expected that this estimate would be accurate within -30 percent to +50 percent.

- **Budget Estimate.** This classification is also known as an "official estimate" and generally intended for pre-design studies. This estimate is prepared to include flow sheets and equipment layouts and details. It is generally expected that this estimate would be accurate within -15 percent to +30 percent.

- **Definitive Estimate.** This classification is also known as a "final estimate" and prepared during the time of contract bidding. The data includes complete plot plans and elevations, and equipment data sheets, and complete specifications. It is generally expected that this estimate would be accurate within -5 percent to +15 percent.

Costs developed in this study should be considered "Order of Magnitude" and have an expected accuracy range of **-30 percent** and **+50 percent**.

8.2 COST ESTIMATE METHODOLOGY

Cost estimates presented in this chapter are opinions of probable construction and other relevant costs developed from several sources including cost curves, Akel experience on other master planning projects, and input from City staff on the development of public and private cost sharing. Where appropriate, costs were escalated to reflect the more current Engineering News Records (ENR) Construction Cost Index (CCI).

This section documents the unit costs used in developing the opinion of probable construction costs, the Construction Cost Index, the land acquisition costs, and markups to account for construction contingency and other project related costs.

8.2.1 Unit Costs

The unit cost estimates used in developing the Capital Improvement Program are summarized on **Table 8.1**. The unit costs are intended for developing the Order of Magnitude estimate, and do not account for site specific conditions, labor or material costs during the time of construction, final project scope, implementation schedule, detailed utility and topography surveys, investigation of alternative routings for pipes, and other various factors. These factors are assumed included in the contingencies applied to the final capital improvement cost.

The unit costs include:

- **Pipeline Unit Costs.** The pipeline unit cost estimates used in developing the CIP are summarized on **Table 8.1**. These costs vary by pipe sizes (up to 21 inches) and are based on the length of pipes, in feet.

- **Pump Station Costs.** These costs are based on a lift station project equation, and were adjusted to reflect the current ENR CCI.

8.2.2 Construction Cost Index

Costs estimated in this study are adjusted utilizing the ENR CCI, which is widely used in the engineering and construction industries.

The costs in this WWMP were benchmarked using a 20-City national average ENR CCI of 10,386, reflecting a date of August 2016.

8.2.3 Construction Contingency Allowance

Knowledge about site-specific conditions for each proposed project is limited at the master planning stage; therefore construction contingencies were used. The estimated construction costs in this master plan include a **25 percent** contingency allowance to account for unforeseen events and unknown field conditions.

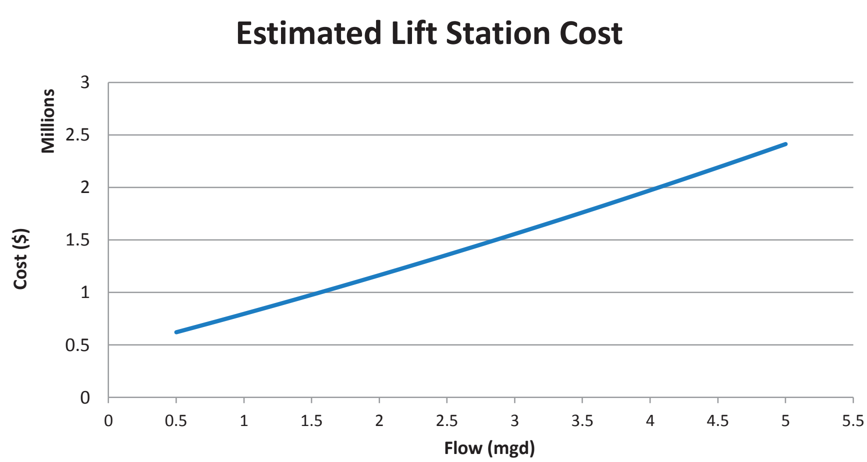
Table 8.1 Unit Costs

Wastewater Master Plan
City of Shasta Lake

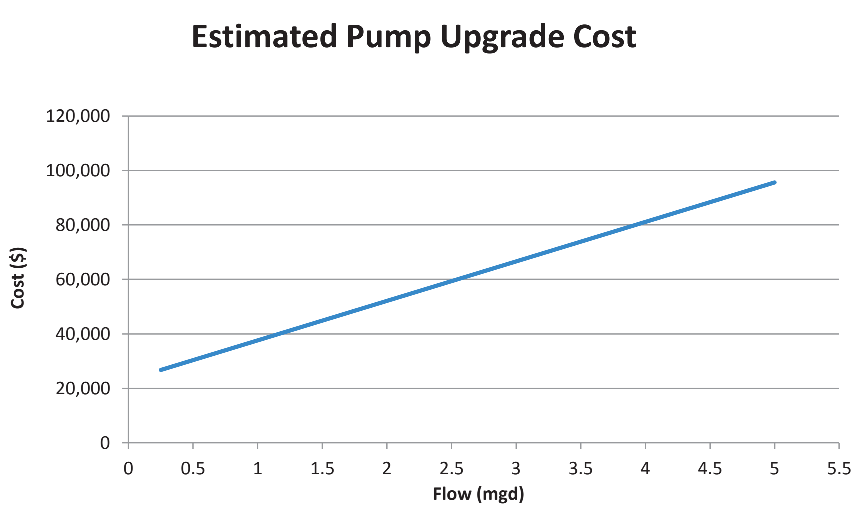
Pipelines				
Pipe Size	Improvement Type Unit Cost			
	New/Parallel/Replacement	CIPP	Cleaning	CCTV
(in)	($/unit length)	($/unit length)	($/unit length)	($/unit length)
6	150	24	1.03	1.29
8	174	37	1.03	1.29
10	198	51	1.03	1.29
12	222	64	1.03	1.29
14	246	77	1.03	1.29
15	258	84	1.03	1.29
18	294	105	1.03	1.29
21	330	125	1.03	1.29

Lift Station

Estimated Lift Station Project Cost = 11,963*Q^2 + 332,885*Q + 450,922 , where Q is in mgd



Estimated Pump Upgrade Cost = 14,486*Q + 23,154, where Q is in mgd



Note : 10/28/2016

1. Unit costs are based on current ENR CCI of 10,386 for August 2016

8.2.4 Project Related Costs

The capital improvement costs also account for project-related costs, comprising of engineering design, project administration (developer and City staff), construction management and inspection, and legal costs. The project related costs in this master plan were estimated by applying an additional **25 percent** to the estimated construction costs.

8.3 CAPITAL IMPROVEMENT PROGRAM

The Capital Improvement Costs for the previously identified projects, shown on **Figure 8.1** are summarized on **Table 8.2**. The Capital Improvement Program lists the type of improvement, location, cost, construction triggers, suggested phasing, and cost sharing.

8.3.1 Pipelines

The recommended pipeline improvements are grouped by collection basin and listed on **Table 8.2**. Each improvement includes a general description of the street alignment and limits as well as existing pipe diameter and length.

The following three pipeline improvements categories were identified:

- **New Pipeline.** The new pipeline is proposed where none exists.
- **Replacement Pipeline.** This improvement is intended as a replacement to an existing pipeline and along the same alignment. The existing pipeline should be abandoned when the replacement pipeline has been constructed.

The opinion of probable construction costs, for the projects included in this master plan, are based on the pipe unit costs summarized on **Table 8.1**.

8.3.2 Construction Triggers

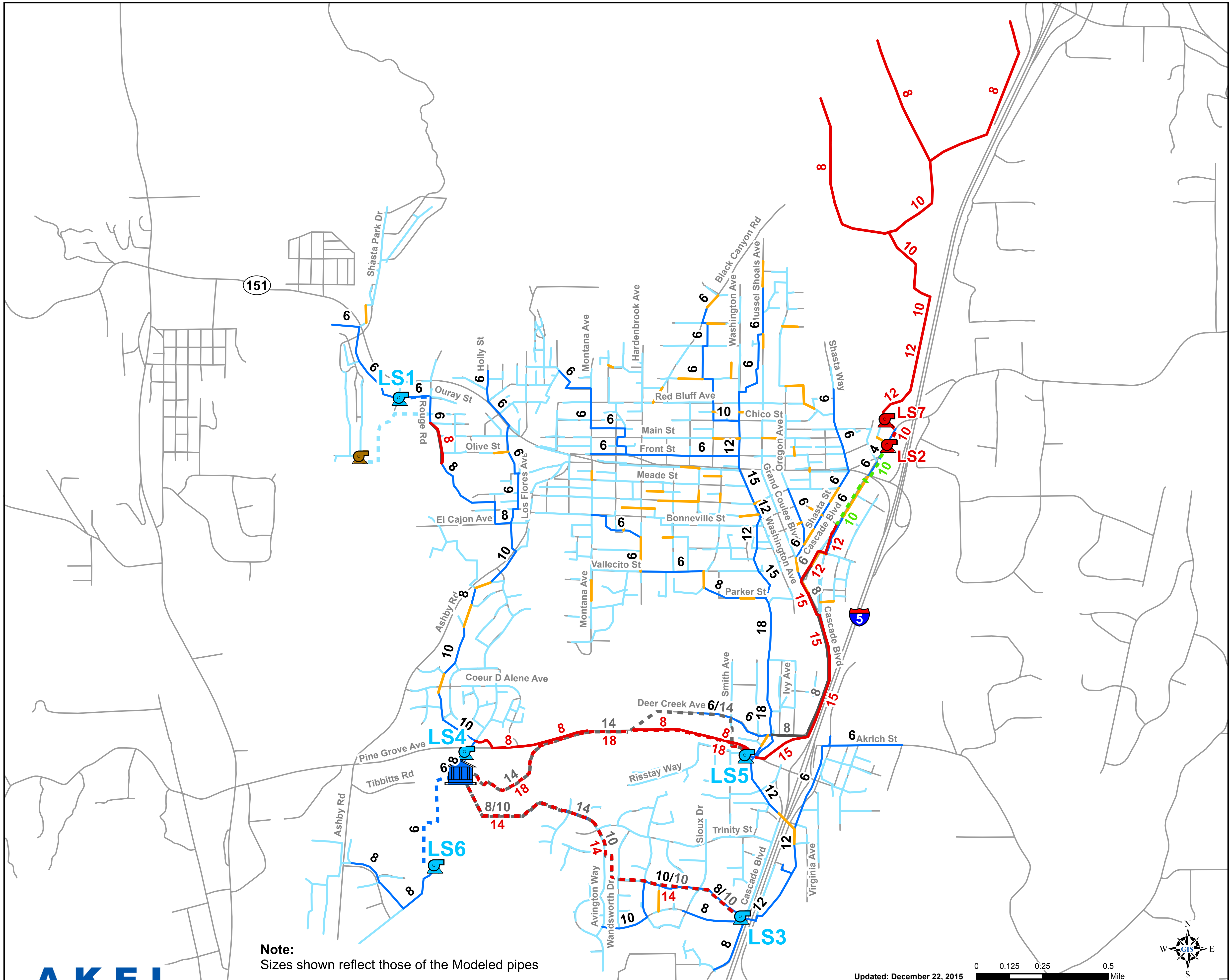
The CIP improvements are prioritized based on their urgency to mitigate existing deficiencies and to serve future growth. The construction triggers for improvements classes are as follows:

Existing Deficiencies

- It is recommended that improvements for the existing deficiencies be constructed as soon as possible.

Future Growth

- The approximate amount of household equivalents (HEs) that may be constructed prior to triggering the need for upgrading the infrastructure are summarized on **Table 8.2**.
- Improvements specifically intended to service future growth may be constructed as development occurs.



Legend

Capacity Improvements

- Lift Stations
- Force Mains
- Existing Force Main Planned for Use
- Gravity Mains

Condition Improvements

- Gravity Mains

Abandoned

- Force Mains
- Gravity Mains

Existing System

- WWTP
- Modeled Lift Stations
- Private Lift Station
- Modeled Force Mains
- Modeled Gravity Mains

Non-Modeled

- Private Force Mains
- Gravity Mains
- Street Centerlines

Figure 8.1
Future System Improvements
Wastewater Master Plan
City of Shasta Lake

CITY OF SHASTA LAKE

AKEL ENGINEERING GROUP, INC.

File Path: P:\xGIS\GIS_Projects\Shasta_Lake\Final-HC\COSL_Fig8-1_FutureSystem_122216.mxd

Table 8.2 Capital Improvement Program

Wastewater Master Plan
City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/ Suggested Rehabilitation	Infrastructure Costs: Diameter (in)	Infrastructure Costs: Length (ft)	Infrastructure Costs: Unit Cost ($/unit)	Infrastructure Costs: Infr. Cost ($)	Baseline Constr. Costs[1] ($)	Estimated Constr. Costs[1,2] ($)	Capital Improv. Costs[1,3] ($)	Construction Trigger	Suggested Phasing	Suggested Cost Allocation: Existing Users (%)	Suggested Cost Allocation: Future Users (%)	Cost Allocation: Existing Users ($)	Cost Allocation: Future Users ($)
Capacity Improvements																		
Pipeline Capacity Improvements																		
PC-1	Gravity Main	Rogue Rd	From Conchas St to 240' s/o Olive St	6	Replace	8	950	174	165,727	165,727	207,158	258,948	Immediate	10 Year	100%	0%	258,948	0
PC-2	Gravity Main	Future ROW	From 1,000' n/o Cascade Blvd to Future LS7	-	New	12	1,300	222	289,184	289,184	361,480	451,850	Construct with development	10 Year	0%	100%	0	451,850
PC-3	Force Main	Future ROW	From LS7 to 270' ne/o intersection of Cascade Blvd and Kennett St	-	New	10	625	198	124,031	124,031	155,038	193,798	Immediate	10 Year	0%	100%	0	193,798
PC-4	Force Main	Existing ROW	From LS3 to WWTP	8/10/14	Replace	14	7,525	246	1,851,150	1,851,150	2,313,938	2,892,422	Immediate	10 Year	95%	5%	2,747,801	144,621
PC-5	Gravity Main	Pine Grove Ave	From 1,700' w/o Jorzack Way to 350' w/o Cascade Blvd	-	New	8	2,525	174	440,484	440,484	550,605	688,256	Construct with development	10 Year	0%	100%	0	688,256
PC-6	Gravity Main	Pine Grove Ave	From 1,600' e/o Coeur D'Alene Ave to 800' w/o Coeur D'Alene Ave	-	New	8	2,375	174	414,316	414,316	517,895	647,369	Construct with development	10 Year	0%	100%	0	647,369
PC-7	Force Main	ROW 60' s/o Pine Grove Ave	From LS5 to WWTP	14	Replace	18	6,775	294	1,994,892	1,994,892	2,493,615	3,117,019	Construct with development	10 Year	53%	47%	1,638,492	1,478,527
PC-8	Gravity Main	ROW	From 4,400' nw/o intersection of Walker Ln and Black Canyon Rd to 4,000' n/o Cascade Blvd	-	New	8	3,550	174	619,294	619,294	774,117	967,647	Construct with development	20 Year	0%	100%	0	967,647
PC-9	Gravity Main	ROW	From 3,700' w/o intersection of HWY-5 and Old Oregon Trl to 4,100' sw/o intersection of HWY-5 and Old Oregon Trl	-	New	8	2,625	174	457,929	457,929	572,411	715,513	Construct with development	20 Year	0%	100%	0	715,513
PC-10	Gravity Main	ROW	From 1,100' w/o intersection of HWY-5 and Old Oregon Trl to 4,100' sw/o intersection of HWY-5 and Old Oregon Trl	-	New	8	3,675	174	641,100	641,100	801,375	1,001,719	Construct with development	20 Year	0%	100%	0	1,001,719
PC-11	Gravity Main	ROW	From 4,100' sw/o intersection of HWY-5 and Old Oregon Trl to 4,000' n/o Cascade Blvd	-	New	10	1,900	198	377,053	377,053	471,316	589,145	Construct with development	20 Year	0%	100%	0	589,145
PC-12	Gravity Main	ROW	From 4,000' n/o Cascade Blvd to 1,900' ne/o Cascade Blvd	-	New	10	2,500	198	496,123	496,123	620,153	775,191	Construct with development	20 Year	0%	100%	0	775,191
PC-13	Gravity Main	ROW	From 1,900' ne/o Cascade Blvd to 1,000' n/o Cascade Blvd		New	12	725	222	161,276	161,276	201,594	251,993	Construct with development	20 Year	0%	100%	0	251,993
PC-14	Gravity Main	Cascade Blvd	From Bonneville St to Joseph St	-	New	12	650	222	144,592	144,592	180,740	225,925	Construct with development	20 Year	100%	0%	225,925	0
PC-15	Gravity Main	Joseph St	From Cascade Blvd to Morning Star Way	6	Replace	12	150	222	33,367	33,367	41,709	52,136	332 HEs	20 Year	6%	94%	3,342	48,795
PC-16	Gravity Main	Morning Star Way	From Joseph St to Grand Coulee Blvd	6	Replace	12	725	222	161,276	161,276	201,594	251,993	397 HEs	20 Year	7%	93%	17,192	234,801
PC-17	Gravity Main	Grand Coulee Blvd	From Morning Star Way to Cascade Blvd	8	Replace	15	825	258	213,220	213,220	266,526	333,157	281 HEs	20 Year	15%	85%	49,512	283,645
PC-18	Gravity Main	Cascade Blvd	From Grand Coulee Blvd to Pine Grove Ave	8	Replace	15	3,725	258	962,723	962,723	1,203,403	1,504,254	880 HEs	20 Year	10%	90%	152,644	1,351,610
						Subtotal - Pipeline Capacity Improvements				9,547,734	11,934,668	14,918,335					**5,093,855**	**9,824,480**
Lift Station Capacity Improvements						Lift Station Capacity (mgd)												
LS-2[4]	Lift Station	Cascade Blvd 700' n/o Shasta Dam Blvd			Replace			-	320,000	320,000	-	-	Construct with development		60%	40%	192,000	128,000
LS-7	Lift Station	Cascade Blvd 700' n/o Shasta Dam Blvd			New	1.6		-	1,014,163	1,014,163	1,267,704	1,584,630	Construct with development		0%	100%	0	1,584,630
						Subtotal - Lift Station Capacity Improvements				1,334,163	1,267,704	1,584,630					**192,000**	**1,712,630**
Pipeline Rehabilitation Improvements																		
Pipeline Replacement Improvements																		
PR-1	Gravity Main	ROW 50' n/o Gray Pine Way	From Locust St to 100' e/o Locust St	6	Replace	8	100	174	17,445	17,445	21,806	27,258	Immediate	10 Year	100%	0%	27,258	0
PR-2	Gravity Main	Black Canyon Rd	From Walker St to 315' n/o Boca St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-4	Gravity Main	Pensacola St	From 230' e/o Black Canyon Rd to 220' w/o Grand River Ave	6	Replace	8	475	174	82,863	82,863	103,579	129,474	Immediate	10 Year	100%	0%	129,474	0
PR-5	Gravity Main	ROW 180' w/o Washington Ave	From 300' n/o Pensacola St to Pensacola St	6	Replace	8	300	174	52,335	52,335	65,418	81,773	Immediate	10 Year	100%	0%	81,773	0
PR-6	Gravity Main	Mussel Shoals Ave	From 230' n/o Koch Rd to 300' s/o Koch Rd	6	Replace	8	500	174	87,225	87,225	109,031	136,288	Immediate	10 Year	100%	0%	136,288	0
PR-7	Gravity Main	Kevin Ln	From Eugene Ave to 300' e/o Eugene Ave	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-8	Gravity Main	Mussel Shoals Ave	From 1,100' n/o Red Bluff St to 1,400' n/o Red Bluff St	6	Replace	8	275	174	47,973	47,973	59,967	74,959	Immediate	10 Year	100%	0%	74,959	0
PR-13	Gravity Main	Main St	From 315' e/o Mussels Shoals Ave to Mussel Shoals Ave	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-14	Gravity Main	ROW 180' e/o Oregon St	From 175' n/o Front St to Front St	6	Replace	8	175	174	30,529	30,529	38,161	47,701	Immediate	10 Year	100%	0%	47,701	0
PR-15	Gravity Main	ROW 330' n/o Kennett St	From 200' w/o Cascade Blvd to Cascade Blvd	6	Replace	8	200	174	34,890	34,890	43,612	54,515	Immediate	10 Year	100%	0%	54,515	0
PR-16	Gravity Main	Cascade Blvd	From Shasta Dam Blvd to Second St	6	Replace	8	375	174	65,418	65,418	81,773	102,216	Immediate	10 Year	100%	0%	102,216	0

Table 8.2 Capital Improvement Program

Wastewater Master Plan
City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/ Suggested Rehabilitation	Infrastructure Costs: Diameter (in)	Infrastructure Costs: Length (ft)	Infrastructure Costs: Unit Cost ($/unit)	Infrastructure Costs: Infr. Cost ($)	Baseline Constr. Consts[1] ($)	Estimated Constr. Costs[1,2] ($)	Capital Improv. Costs[1,3] ($)	Construction Trigger	Suggested Phasing	Suggested Cost Allocation: Existing Users (%)	Suggested Cost Allocation: Future Users (%)	Cost Allocation: Existing Users ($)	Cost Allocation: Future Users ($)
PR-18	Gravity Main	Morning Star Way	From Joseph St to 330' s/o Joseph St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-19	Gravity Main	Bonneville St	From 320' w/o Shasta St to Shasta St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-20	Gravity Main	Boulder St	From 180' w/o Oregon St to Oregon St	6	Replace	8	175	174	30,529	30,529	38,161	47,701	Immediate	10 Year	100%	0%	47,701	0
PR-21	Gravity Main	Shasta St	From 675' n/o Grand Coulee Blvd to 330' n/o Grand Coulee Blvd	6	Replace	8	350	174	61,057	61,057	76,321	95,402	Immediate	10 Year	100%	0%	95,402	0
PR-22	Gravity Main	Fort Peck St	From 170' e/o Washington Ave to Washington Ave	6	Replace	8	175	174	30,529	30,529	38,161	47,701	Immediate	10 Year	100%	0%	47,701	0
PR-23	Gravity Main	ROW 210' n/o Bonneville St	From 380' w/o Washington Ave to Washington Ave	6	Replace	8	375	174	65,418	65,418	81,773	102,216	Immediate	10 Year	100%	0%	102,216	0
PR-25	Gravity Main	Deer Creek Rd	From 160' n/o Fort Peck St to Fort Peck St	6	Replace	8	150	174	26,167	26,167	32,709	40,886	Immediate	10 Year	100%	0%	40,886	0
PR-26	Gravity Main	Alley n/o Meade St	From 340' w/o Deer Creek Rd to Deer Creek Rd	6	Replace	8	350	174	61,057	61,057	76,321	95,402	Immediate	10 Year	100%	0%	95,402	0
PR-29	Gravity Main	Alley n/o Fort Peck St	From 550' w/o Cabello St to 200' w/o Cabello St	6	Replace	8	325	174	56,696	56,696	70,870	88,587	Immediate	10 Year	100%	0%	88,587	0
PR-31	Gravity Main	Alley n/o La Mesa Ave	From 275' e/o Hardenbrook Ave to Hardenbrook Ave	6	Replace	8	275	174	47,973	47,973	59,967	74,959	Immediate	10 Year	100%	0%	74,959	0
PR-33	Gravity Main	ROW 175' e/o Locust Ave	From 120' n/o Winteramber Ct to Winter Amber Ct	6	Replace	8	125	174	21,806	21,806	27,258	34,072	Immediate	10 Year	100%	0%	34,072	0
PR-35	Gravity Main	Montana Ave	From 410' s/o Vallecito St to Vallecito St	6	Replace	8	400	174	69,780	69,780	87,225	109,031	Immediate	10 Year	100%	0%	109,031	0
									Subtotal - Pipeline Condition Replacement Improvements	1,173,170	1,466,462	1,833,077					**1,833,077**	**0**
Defect Repair Improvements																		
PR-3	Gravity Main	Boca St	From 300' w/o Washington Ave to 150' e/o Black Canyon Rd	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-9	Gravity Main	Dyke St	From Oregon St to 350' e/o Oregon St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-10	Gravity Main	ROW 350' e/o Oregon St	From Red Bluff St to Dyke St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-11	Gravity Main	ROW 340' w/o Oregon St	From Red Bluff St cul-de-sac to 90' n/o Chico St cul-de-sac	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-12	Gravity Main	ROW 175' s/o Red Bluff St	From 300' e/o Washington St to Washington St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-17	Gravity Main	Joseph St	From Cascade St to Morning Star Way	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-24	Gravity Main	ROW 300' w/o Ellen Dr	From Vallecito St to 330' s/o Vallecito St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-27	Gravity Main	Shasta Dam Blvd	From 370' w/o Stanton Ave to Stanton Ave	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-28	Gravity Main	Stanton Ave	From 220' n/o Fort Peck St to Fort Peck St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-30	Gravity Main	Fort Peck St	From 300' w/o Cabello St to Cabello St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-32	Gravity Main	Alley n/o La Mesa Ave	From 640' w/o Hardenbrook Ave to Hardenbrook Ave	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-34	Gravity Main	ROW 200' s/o Bonneville St	From 200' w/o Cabello St to Cabello St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-36	Gravity Main	Montana Ave	From 175' n/o Meade St to Meade St	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
PR-37	Gravity Main	ROW 100' w/o Shasta Park Dr	From 550' n/o Twin Lake Dr to 210' n/o Twin Lake Dr	6	Repair	6	20	150	3,009	3,009	3,761	4,702	Immediate	10 Year	100%	0%	4,702	0
									Subtotal - Pipeline Defect Repair Improvements	42,126	52,657	65,821					**65,821**	**0**
Infiltration Improvements																		
PI-1	Gravity Main	Boudreaux Pl	From 360' n/o Red Bluff St to Red Bluff St	6	Lining		350	24	8,330	8,330	10,412	13,015	Immediate	10 Year	100%	0%	13,015	0
PI-2	Gravity Main	ROW 150' n/o Chico St	From Grand River Ave to 280' e/o Grand River Ave	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-3	Gravity Main	Main St	From Grand River Ave to Washington Ave	6	Lining		525	24	12,494	12,494	15,618	19,523	Immediate	10 Year	100%	0%	19,523	0
PI-4	Gravity Main	ROW 500' e/o Oregon St	From 50' n/o Shasta Dam Blvd to 30' s/o Shasta Dam Blvd	6	Lining		75	24	1,785	1,785	2,231	2,789	Immediate	10 Year	100%	0%	2,789	0
PI-5	Gravity Main	Shasta St	From Fort Peck St to 320' s/o Fort Peck St	6	Lining		325	24	7,735	7,735	9,668	12,085	Immediate	10 Year	100%	0%	12,085	0
PI-6	Gravity Main	Cascade Blvd	From Shasta Dam Blvd to Second St	6	Lining		375	24	8,925	8,925	11,156	13,945	Immediate	10 Year	100%	0%	13,945	0
PI-7	Gravity Main	Cascade Blvd	From Second St to Third St	6	Lining		500	24	11,899	11,899	14,874	18,593	Immediate	10 Year	100%	0%	18,593	0

Table 8.2 Capital Improvement Program

Wastewater Master Plan

City of Shasta Lake

Improv. No.	Improv. Type	Alignment	Limits	Pipeline Improvements: Existing Diameter (in)	Pipeline Improvements: New/ Suggested Rehabilitation	Infrastructure Costs: Diameter (in)	Infrastructure Costs: Length (ft)	Infrastructure Costs: Unit Cost ($/unit)	Infrastructure Costs: Infr. Cost ($)	Baseline Constr. Costs[1] ($)	Estimated Constr. Costs[1,2] ($)	Capital Improv. Costs[1,3] ($)	Construction Trigger	Suggested Phasing	Suggested Cost Allocation: Existing Users (%)	Suggested Cost Allocation: Future Users (%)	Cost Allocation: Existing Users ($)	Cost Allocation: Future Users ($)
PI-8	Gravity Main	Grand Coulee Blvd	From Shasta St to 260' s/o Shasta St	8	Lining		250	37	9,313	9,313	11,641	14,551	Immediate	10 Year	100%	0%	14,551	0
PI-9	Gravity Main	Grand Coulee Blvd	From Morning Star Way to 280' s/o Morning Star Way	8	Lining		275	37	10,244	10,244	12,805	16,006	Immediate	10 Year	100%	0%	16,006	0
PI-10	Gravity Main	ROW 200' s/o Elliott St	From Rosamond St to Cascade Blvd	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-11	Gravity Main	Parker St	From 430' e/o Ellen St to 610' e/o Ellen St	8	Lining		275	37	10,244	10,244	12,805	16,006	Immediate	10 Year	100%	0%	16,006	0
PI-12	Gravity Main	Fort Peck St	From Cabello St to Stanton Ave	6	Lining		500	24	11,899	11,899	14,874	18,593	Immediate	10 Year	100%	0%	18,593	0
PI-13	Gravity Main	Hardenbrook Ave	From 270' n/o Willamette St to Willamette St	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-14	Gravity Main	Hardenbrook Ave	From Willamette St to Vallecito St	6	Lining		400	24	9,520	9,520	11,899	14,874	Immediate	10 Year	100%	0%	14,874	0
PI-15	Gravity Main	Olive St	From 290' w/o Givan St to Givan St	6	Lining		275	24	6,545	6,545	8,181	10,226	Immediate	10 Year	100%	0%	10,226	0
PI-16	Gravity Main	ROW 130' e/o Ashby Rd	From 290' w/o Woodley Ave to 590' w/o Woodley Ave	8	Lining		325	37	12,106	12,106	15,133	18,916	Immediate	10 Year	100%	0%	18,916	0
PI-17	Gravity Main	ROW 150' e/o Ashby Rd	From 270' sw/o Wellington Pl to 340' nw/o Bloomsbury Ave	8	Lining		450	37	16,763	16,763	20,953	26,192	Immediate	10 Year	100%	0%	26,192	0
PI-18	Gravity Main	ROW 190' w/o Walton Ave	From 270' n/o Coeur D'Alene Ave to 120' s/o Coeur D'Alene Ave	10	Lining		375	51	19,013	19,013	23,767	29,708	Immediate	10 Year	100%	0%	29,708	0
PI-19	Gravity Main	ROW 180' nw/o Cascade Blvd	From Deer Creek Blvd to 200' n/o Pine Grove Ave	12	Lining		250	64	16,038	16,038	20,048	25,060	Immediate	10 Year	100%	0%	25,060	0
PI-20	Gravity Main	HWY-5	From Humboldt St to Poppy Ln	12	Lining		450	64	28,869	28,869	36,086	45,108	Immediate	10 Year	100%	0%	45,108	0
PI-21	Gravity Main	ROW 250' w/o Larkin Ave	From Poppy Ln to 290' s/o Poppy Ln	12	Lining		300	64	19,246	19,246	24,058	30,072	Immediate	10 Year	100%	0%	30,072	0
PI-22	Gravity Main	Greenwich Dr	From 400' n/o Autumn Harvest Way to Autumn Harvest Way	8	Lining		400	37	14,900	14,900	18,625	23,282	Immediate	10 Year	100%	0%	23,282	0
									Subtotal - Pipeline Infiltration Improvements	255,502	319,378	399,222					399,222	0

Total Pipeline Improvement Cost

	Existing Users ($)	Future Users ($)
Pipeline Capacity Improvements	5,093,855	9,824,480
Lift Station Improvements	192,000	1,712,630
Pipeline Condition Replacement Improvements	1,833,077	0
Pipeline Defect Repair Improvements	65,821	0
Pipeline Infiltration Improvements	399,222	0
Total Improvement Costs $19,121,086	**7,583,976**	**11,537,111**

Notes:

1. Costs are based on current ENR CCI of 10,386 for August 2016
2. Baseline construction costs plus 25% to account for unforeseen events and unknown conditions.
3. Estimated construction cost plus 25% to cover other costs including: engineering design, project administration (developer and City staff), construction management and inspection, and legal costs.
4. Lift Station 2 Baseline Construction Cost based on estimate received from City staff October 3, 2016. Cost sharing percentages based on capacity and required facility upgrades for existing users.

12/13/2016

8.3.3 Construction Phasing

The Capital Improvement Program was divided into the following phases:

- **10-Year:** This near-term phase consists of improvements for FY 2016 through FY 2025 that are required to resolve existing deficiencies, as well as service future growth.

- **20-Year:** This long-term phase consists of improvements for FY 2026 through FY 2035 that are required to service future growth.

This phasing plan is subject to revisions by City staff based on how new developments occur.

8.3.4 Recommended Cost Allocation Analysis

Capacity allocation analysis is needed to identify improvement funding sources, and to establish a nexus between development impact fees and improvements needed to service growth. In compliance with the provisions of Assembly Bill AB 1600, the analysis differentiates between the project needs of servicing existing users and for those required to service anticipated future developments. **Table 8.2** lists each improvement and separates the cost by responsibility between existing and future users. The cost responsibility is based on model parameters for existing and future land use, and may change depending on the nature of development.

8.4 FINANCIAL CONSTRAINTS

The 2014 City of Shasta Lake Water and Wastewater Utility Rate Update was the basis for the financial constraints analysis included as part of this master plan. This analysis include estimating the available capital improvement funds for fiscal year FY 2013 and FY 2014. The following assumptions, which were documented in the 2014 Rate Update, were used to estimate the annual available funds through FY 2024 (**Table 8.3**):

- Interest earnings equal to 1%of the Beginning Fund Available Balance.
- Annual rate increase equal to 3.5% per fiscal year.
- Wastewater administration expenditures subjected to an increase of 4.3% per fiscal year.
- Treatment facility and collection system costs subject to an increase of 2.5% per fiscal year.
- Operating reserve equal to 8% of fiscal year revenue.

It is estimated, between FY 2016 and FY 2024, the City will have a total of more than $11,000,000 to allocate to the completion of capital projects.

Table 8.3 Financial Constraints

Wastewater Master Plan
City of Shasta Lake

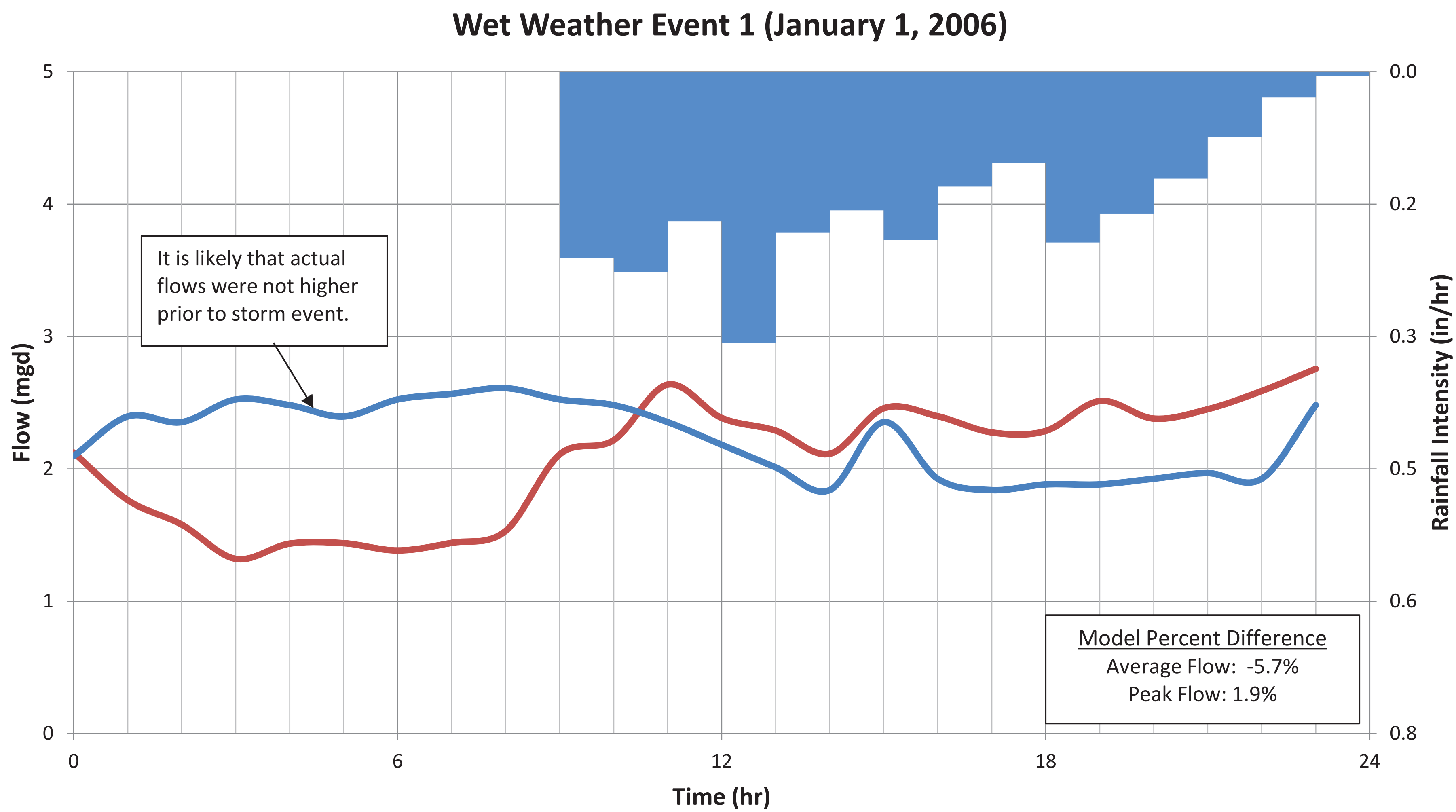
	FY 13-14	FY 14-15	FY 15-16	FY 16-17	FY 17-18	FY 18-19	FY 19-20	FY 20-21	FY 21-22	FY 22-23	FY 23-24	FY 24-25
WasteWater Rates Used												
Single Family Monthly Service Charge	$56.70	$58.40	$60.45	$62.56	$64.75	$67.02	$69.37	$71.79	$74.31	$76.91	$79.60	$82.38
Lifeline Single Family Monthly Service Charge	$43.36	$46.72	$48.36	$50.05	$51.80	$53.61	$55.49	$57.43	$59.44	$61.52	$63.67	$65.90
Rate Increase[1]		3.00%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
Estimated number of Housing Equivalents (HE)												
Beginning of year HEs	3,879	3,889	3,899	3,919	3,956	3,994	4,032	4,070	4,109	4,148	4,188	4,228
Estimated additional HEs[2]	10	10	20	37	38	38	38	39	39	40	40	40
Estimated Year End HEs	3,889	3,899	3,919	3,956	3,994	4,032	4,070	4,109	4,148	4,188	4,228	4,268
Estimated Year End Lifeline	359	359	359	359	359	359	359	359	359	359	359	359
Beginning Funds Available Balance[3]												
	$1,894,250	$1,017,768	$673,315	$450,609	$324,678	$422,329	$274,304	$286,004	$298,397	$311,312	$324,845	$338,949
Revenues												
Service Charges	$2,588,607	$2,682,102	$2,790,759	$2,915,955	$3,047,549	$3,184,925	$3,328,029	$3,478,109	$3,634,618	$3,798,745	$3,969,909	$4,148,400
Sales on Reclaimed Water	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
Service Connections	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400	$400
Interest Earnings[4]	$8,500	$10,178	$6,733	$4,506	$3,247	$4,223	$2,743	$2,860	$2,984	$3,113	$3,248	$3,389
Pasture Rent	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400
Other Operation Income	$800	$800	$800	$800	$800	$800	$800	$800	$800	$800	$800	$800
Transfer from P&FCC Fund[5]	$46,601	$75,496	$140,917	$222,081	$226,523	$231,053	$235,674	$240,388	$245,195	$250,099	$255,101	$260,203
Total	2,652,308	2,776,375	2,947,009	3,151,142	3,285,919	3,428,802	3,575,046	3,729,957	3,891,397	4,060,557	4,236,858	4,420,593
Expenditures												
WasteWater Administration[6]	$527,281	$549,954	$573,602	$598,267	$623,992	$650,824	$678,810	$707,998	$738,442	$770,195	$803,314	$837,856
Treatment Facility[7]	$681,954	$698,965	$728,156	$734,275	$752,632	$771,448	$790,734	$810,502	$830,765	$851,534	$872,822	$894,643
Collection System[7]	$755,814	$841,909	$862,957	$884,531	$906,644	$929,310	$952,543	$976,357	$1,000,766	$1,025,785	$1,051,429	$1,077,715
Transfers to Capital Improvements Fund[8]	$1,563,741	$1,030,000	$1,005,000	$1,060,000	$905,000	$1,225,244	$1,141,260	$1,222,706	$1,308,509	$1,399,511	$1,495,189	$1,595,680
Total	$3,528,790	$3,120,828	$3,169,715	$3,277,073	$3,188,269	$3,576,826	$3,563,346	$3,717,564	$3,878,482	$4,047,025	$4,222,754	$4,405,894
Ending Balance/Operating Reserve[9]												
	$1,017,768	$673,315	$450,609	$324,678	$422,329	$274,304	$286,004	$298,397	$311,312	$324,845	$338,949	$353,647

Notes : 10/5/2016

1. Rate increase based on the rate study provided by the City Staff on 7/27/2016.
2. Based on future population growth (asssuming 2.55 persons per housing equivalent).
3. Equal to the ending balance of the previous fiscal year.
4. Interest earnings equal to 1% of the Beginning Fund Available Balance.
5. Transfer from P&FCC Fund subject to an increase rate of 2% following FY 17-18, For previous fiscal years, information extracted from previous rate study provided by the City Staff on 7/27/2016.
6. Wastewater Administration expenditure subject to an increase of 4.3% following FY 14-15, For previous fiscal years, information extracted from previous rate study provided by the City Staff.
7. Treatment Facility and Collection System subject to an increase of 2.5% following FY 17-18, For previous fiscal years, information extracted from previous rate study provided by the City Staff.
8. For FY 13-14 to FY 18-19, Capital Improvemnts funds were extracted from previous rate study provided by the City Staff on 7/27/2016.
9. Operating Reserve made equal to 8% of the revenues for the Fiscal Year.

APPENDICES

APPENDIX A
Hydraulic Model Calibration Exhibits



LEGEND

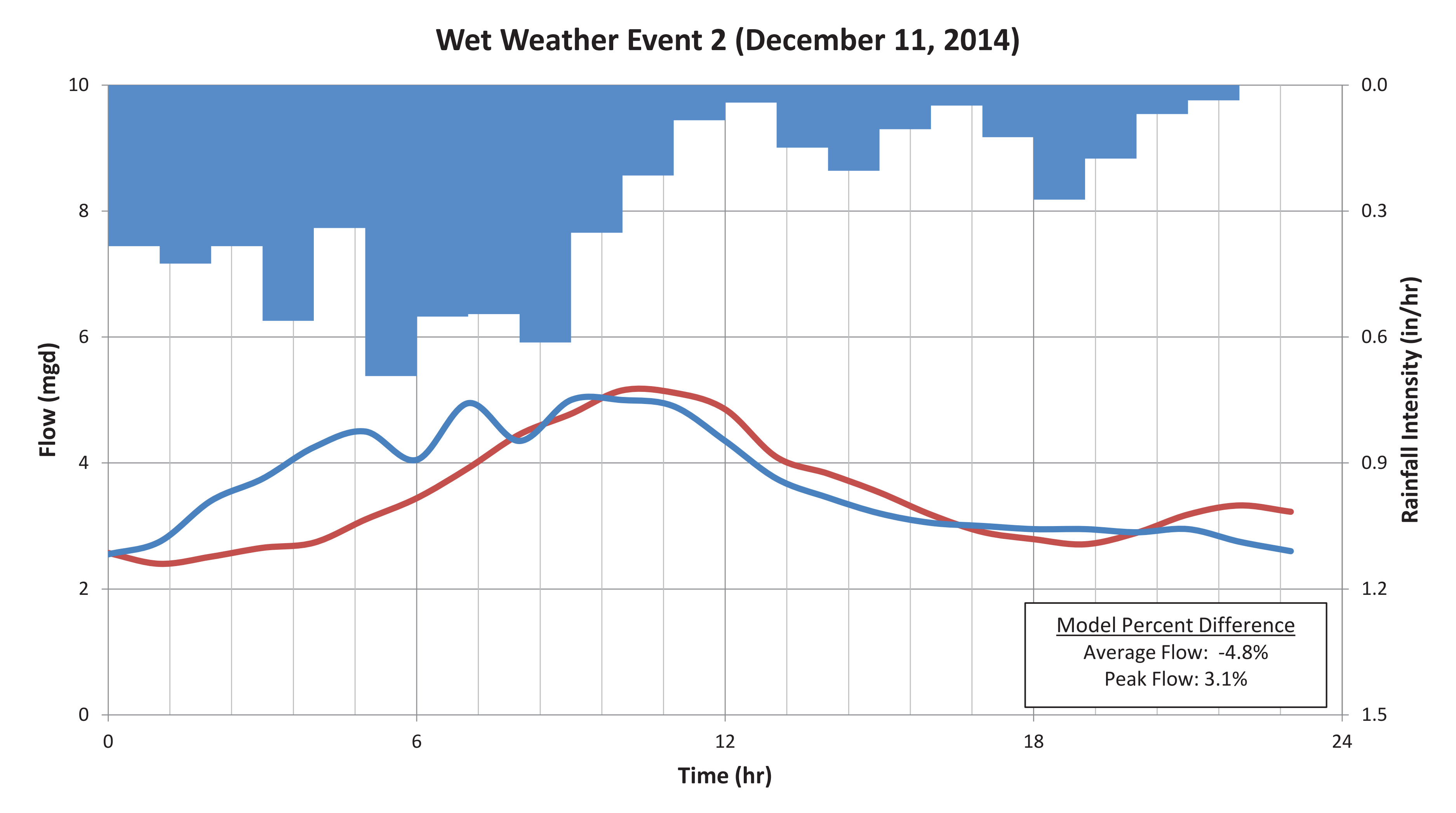
- Recorded WWTP Flow
- Hydraulic Model
- Rain Event

AKEL ENGINEERING GROUP, INC.

August 17, 2016

Figure 1
Wet Weather Flow
Model Calibration

Wastewater Collection System
Master Plan
City of Shasta Lake



LEGEND

- Recorded WWTP Flow
- Hydraulic Model
- Rain Event

Note: The peak hour flow during the wet weather event exceeded the operating range of the WWTP data recorder.

August 17, 2016

Figure 2

Wet Weather Flow

Model Calibration

Wastewater Collection System
Master Plan
City of Shasta Lake

AKEL ENGINEERING GROUP, INC.

This study was partially funded by a CDBG
Planning and Technical Assistance Grant
from the State of California Housing and Community Development